Reunión de América del Norte sobre la Mariposa Monarca, 1997

1997 North American Conference on the Monarch Butterfly

Ponencias: biología, conservación, sustentabilidad y desarrollo, y educación ambiental

Paper Presentations: Biology, Conservation, Sustainability and Development, and Environmental Education

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Prefacio

Hace más de 20 años, los canadienses Fred y Norah Urquhart encontraron por fin la respuesta al misterio que los había perseguido por décadas: el destino de las mariposas monarca cuando comenzaban las bajas temperaturas y el frío invierno de América del Norte. La llegada y partida de las monarca era un hecho tan notorio y bien conocido en Estados Unidos y Canadá como lo era en la cordillera neovolcánica en el centro de México. Sin embargo, en ambos casos era un misterio a dónde iban y de dónde venían. Tras muchos años de investigación cuidadosa e intensa, un colega estadounidense de los Urquhart, Ken Brugger, con ayuda de su esposa mexicana, Catalina Aguado, y de un guía local, encontró el lugar al que las monarca llegaban luego de viajar unos cuatro mil kilómetros: los bosques montañosos ubicados entre los estados de Michoacán y México. En poco tiempo, los detalles de este hermoso y complejo fenómeno migratorio fueron ampliamente conocidos, pero en igual medida lo fue el cúmulo de dificultades que entrañaba la conservación de esas mariposas.

Voluntarios y profesionales, maestros y periodistas, adultos y niños vigilan ahora con gran celo —al amparo de diversos programas— a las monarca que llegan y parten de los lugares del norte. Se han celebrado dos conferencias internacionales: el Simposio sobre la Biología y la Conservación de las Mariposas Monarca (Morelos, México, 1981) y la Segunda Conferencia Internacional sobre las Mariposas Monarca (Los Ángeles, California, 1986). Se recurre a las monarca como un ejemplo clásico de los programas de educación medioambiental; en tratándose de contemplar la belleza y la complejidad del mundo natural, destacan por su profunda elegancia. Joyas vivas y delicadas en virtud de sus prolongadas jornadas migratorias, representan un activo común y, por ende, una responsabilidad compartida para los tres países de América del Norte. Cada uno alberga alguna combinación de hábitats en los que la monarca se reproduce, emigra o invierna; proteger cada uno de estos hábitats requiere de diversos recursos. El debilitamiento de cualquiera de los eslabones de esta cadena amenaza con la destrucción total del fenómeno migratorio. Sin embargo, al igual que los hábitats de las monarca son distintos en toda América del Norte, distintas deben ser las estrategias de conservación de los tres países. Aunque cada país debe contribuir a los esfuerzos de conservación, la elevadísima concentración de las monarca en los sitios de invernación de México hacen que éstos sean el eslabón potencialmente débil, acaso el desafío más importante para la conservación de las mariposas monarca.

Los bosques donde las poblaciones orientales de las monarca sobreviven al invierno constituyen fuentes de ingreso importantes para la creciente población humana del área. Ahí las monarca se conocen como "cosechadoras" debido a la fase del ciclo agrícola en que llegan. Comparten los bosques con las culturas indígenas y campesinas, que las conocen muy bien. La interacción de los asentamientos humanos, el bosque y las monarca en México, aunque data de siglos, no ha sido sencilla, sobre todo durante los recientes 15 años.

Los numerosos retos que entraña la conservación de las monarca representan una oportunidad para la cooperación ambiental entre los tres países signatarios del Tratado de Libre Comercio de América del Norte (TLC). Conservar una especie, como la mariposa monarca, la cual constituye un vínculo entre los tres países, exige una buena dosis de cooperación y compromiso. Presenta el reto de actuar de manera conjunta sin dejar de tomar en cuenta las diferencias culturales, jurídicas e históricas. Si se realizan adecuadamente, estas actividades pueden conducir a la conservación a largo plazo de la monarca, su ciclo migratorio y los bosques y plantas de los que depende, sin comprometer aún más los niveles de vida de aquellos con quienes comparte sus hábitats.

A juicio de la Comisión para la Cooperación Ambiental (CCA), la formulación de una sólida estrategia de conservación de largo plazo exige, con apremio, un intercambio libre y abierto de ideas e información entre todos aquellos a quienes les concierne. Por ello, la CCA organizó la Reunión de América del Norte sobre la Mariposa Monarca (RANMM) en noviembre de 1997 en Morelia, Michoacán, México, a la que asistieron numerosas organizaciones gubernamentales y no gubernamentales, así como académicos, campesinos, educadores, periodistas y artistas.

Aunque fueron todo un éxito porque apuntaron los reflectores hacia las mariposas monarca, las primeras dos conferencias se centraron sobre todo en su biología. Los organizadores de la conferencia consideraron que se tendrían más frutos si se lograba la participación de un grupo antes pasado por alto: los campesinos, dueños ancestrales de las tierras mexicanas en que las monarca sobreviven al invierno. Durante la conferencia, un diálogo abierto y amplio condujo a la búsqueda de compromisos y soluciones conjuntos; a menudo se fue más allá del simple análisis de datos y cifras hasta identificar prioridades y oportunidades para las actividades de cooperación.

Es muy importante para la CCA difundir hasta donde sea posible las discusiones y documentos de la conferencia. Por esta razón, tenemos el placer de presentar la *Reunión de América del Norte 1997 sobre la Mariposa Monarca* (*Ponencias*), como un elemento más en la búsqueda de medidas de cooperación entre los tres grandes países de América del Norte.

Irene Pisanty
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Secretariado de la Comisión para la Cooperación Ambiental

Preface

More than twenty years ago, Canadians Fred and Norah Urquhart finally found the answer to a mystery that had haunted them for decades: the fate of monarch butterflies once temperatures lowered and the cold North American winter started. The arrival and departure of the monarchs was an event as notable and well known in the United States and Canada as it was to the inhabitants of the Transverse Neovolcanic Belt in central Mexico. In both cases, however, where the monarchs went and from where they came were mysteries. After many years of careful and intensive research, an American colleague of the Urquharts, Ken Brugger, assisted by his Mexican wife, Catalina Aguado, and by a local guide, found the place where the monarchs arrived after traveling approximately four thousand kilometers. In a short time, the discovery of such a complex and beautiful migration process was well and widely known. The huge interest that this migratory phenomenon arose quickly made evident the multiple and inherent possibilities, as well as difficulties, involved in its conservation.

The arrival and departure of monarchs to and from the northern sites is now carefully followed by amateurs and professionals, by teachers and journalists, by adults and children through many different monitoring programs. Two international conferences have taken place: the Symposium on the Biology and Conservation of the Monarch Butterfly (Morelos, Mexico, 1981) and the Second International Conference on the Monarch Butterfly (Los Angeles, California, 1986). Monarchs are used as a classic example in environmental education programs. And when the beauty and complexity of the natural world are discussed, monarchs are a key example. They represent a shared richness and, consequently, also a shared responsibility for all three countries in North America. Each country contains some combination of habitats in which monarchs breed, migrate or overwinter, and each of these stages requires different resources. Any weak link in this chain of habitats threatens to destroy the entire migratory phenomenon. However, just as the monarch habitats in North America differ, conservation strategies of the three countries differ as well. Although each country must contribute to conservation efforts, the incredibly high concentration of monarchs in the Mexican overwintering sites means that this link is potentially the weakest. Thus, an important challenge for monarch conservation is found in Mexico.

The forests where the eastern population of monarchs overwinter comprise important sources of income for the growing human population of this area. Known as “harvesters,” due to the phase of the agricultural cycle when they arrive, the monarch population shares the forests with indigenous and peasant cultures. These people are well acquainted with the monarchs, and even though the interaction between the human settlements, the forest and the monarchs in Mexico is centuries old, it has not been a simple one, especially during the last fifteen years.

The many challenges posed by the conservation of the monarchs represent an opportunity for environmental cooperation for the three North American Free Trade Agreement (NAFTA) countries. This natural link demands a high degree of cooperation and compromise between these countries. It poses the challenge of developing actions jointly, which must take into account cultural, legal and traditional differences. These actions, if properly developed, can lead to long-term conservation of the monarchs, their migratory cycle, and the forests and plants upon which they depend without further compromising the life standards of the people with whom they share their habitats.

For the Commission for Environmental Cooperation (CEC), an open and free exchange of ideas and information between all stakeholders involved is an urgent necessity if a strong, long-term conservation strategy is to be had. Thus, the CEC undertook the organization of the North American Conference on the Monarch Butterfly (NACMB), which took place in November 1997, in Morelia, Michoacán, México. Numerous governmental and non governmental organizations participated in the Conference, as well as academics, *campesinos*, educators, journalists and artists.

Although the first two conferences were successful in attracting wide attention to the monarch butterfly, they focused mainly on its biology. Organizers of the Morelia conference felt that more could be achieved if they involved a previously overlooked group of stakeholders: the *campesinos*, historical landowners of the monarch overwintering sites in Mexico. During the Conference, an open and wide dialogue led to the search of joint efforts and solutions. This dialogue very frequently went beyond simple discussion of facts and figures—it led to the implementation of actions which are subsequently becoming a reality.

Making the contents of the NACMB widely accessible is of major importance for the Commission for Environmental Cooperation. Thus, we are pleased to present the 1997 North American Conference on the Monarch Butterfly: Paper Presentations, as a further element in the search of cooperative measures between the three great countries of North America.

Irene Pisanty
Project Manager, Ecosystem Protection
Commission for Environmental Cooperation

Agradecimientos

Este primer volumen de las memorias de la Conferencia de América del Norte sobre la Mariposa Monarca 1997 no se hubiera realizado sin el tiempo y el esfuerzo que tantas personas le dedicaron a la organización y edición de los materiales. La Comisión para la Cooperación Ambiental (CCA) agradece en particular al equipo editorial sus empeños para la publicación de estos documentos.

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Tara Wilkinson Coordinadora de la Conferencia de América del Norte sobre la Mariposa Monarca 1997: Presentación de Ponencias

La CCA también manifiesta su gratitud al Comité Permanente de la Conferencia de América del Norte sobre la Mariposa Monarca por su participación en esta empresa. Por Canadá: Kathryn Dickson (Environment Canada, Canadian Wildlife Service); Steven Price (World Wildlife Fund); Phil Schappert (York University), y Steve Wendt (Environment Canada, Canadian Wildlife Service). Por México: Pedro Álvarez Icaza (Instituto Nacional de Ecología); Ma. Eugenia Ayala (Semarnap [únicamente para la parte logística]); Javier de la Maza (Sistema Nacional de Áreas Naturales Protegidas); Magdalena García (Instituto Nacional de Ecología); Luciano Grobet (Delegación de Semarnap en Morelia); Jürgen Hoth (Embajada de México en Canadá); Leticia Merino (Centro Regional de Investigaciones Multidisciplinarias, Universidad Nacional Autónoma de México y Consejo Civil Mexicano para la Silvicultura Sustentable); Alberto Rojas (Delegación de Semarnap en Morelia), y Roberto Solís (Reserva de la Biosfera Mariposa Monarca). Por Estados Unidos: Maria Araujo (Texas Parks and Wildlife); Ellen Murphy (International Relations, Fish and Wildlife Service, Departamento del Interior); Karen Oberhauser (Universidad de Minnesota), y Herb Raffaelle (International Relations, Fish and Wildlife Service, Departamento del Interior). Por la CCA: Irene Pisanty (coordinadora del Programa de Protección de los Ecosistemas), Leticia Villeneuve (coordinación de eventos especiales), Rachel Vincent (comunicaciones) y Tara Wilkinson (asistente de coordinación).

Por último, la CCA agradece a los numerosos asistentes su intensa participación antes, durante y después de la Conferencia. Sin su activa y entusiasta presencia, sin su espíritu de cooperación, el acontecimiento nunca habría cristalizado.

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The proceedings of the 1997 North American Conference on the Monarch Butterfly: Paper Presentations could not have been realized without the time and effort of the many people involved in the organization of the conference and the editing of the proceedings. In particular, the Commission for Environmental Cooperation (CEC) is very grateful to the editorial team for the tasks they have undertaken throughout the creation of these proceedings.

For the editorial team:

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The CEC would also like to express its appreciation to the Steering Committee of North American Conference on the Monarch Butterfly for their work in this endeavor: for Canada, Kathryn Dickson (Environment Canada, Canadian Wildlife Service), Steven Price (World Wildlife Fund), Phil Schappert (York University), Steve Wendt (Environment Canada, Canadian Wildlife Service); for Mexico, Pedro Alvarez Icaza (*Instituto Nacional de Ecología*), Ma. Eugenia Ayala (*Semarnap* [for its contribution to the logistics of the conference]), Javier de la Maza (*Sistema Nacional de Areas Naturales Protegidas*), Magdalena García (*Instituto Nacional de Ecología*), Luciano Grobet, (*Delegación de Semarnap en Morelia*), Jürgen Hoth (*Embajada de México en Canadá*), Leticia Merino (*Centro Regional de Investigaciones Multidisciplinarias, Universidad Nacional Autónoma de México y Consejo Civil Mexicano para la Silvicultura Sustentable*), Alberto Rojas (*Delegación de Semarnap en Morelia*), Roberto Solís (*Reserva de la Biosfera Mariposa Monarca*); for the United States, Maria Araujo (Texas Parks and Wildlife), Ellen Murphy (International Relations, Fish and Wildlife Service, Department of the Interior), Karen Oberhauser (University of Minnesota), Herb Raffaelle (International Relations, Fish and Wildlife Service, Department of the Interior); and for the CEC, Irene Pisanty (Program Manager, Ecosystem Protection), Leticia Villeneuve (Coordination of special events), Rachel Vincent (Communications), and Tara Wilkinson (Coordination assistant).

Finally, the CEC would also like to thank the numerous attendees of North American Conference on the Monarch Butterfly for their extensive participation before, during, and after the conference. Without their active, enthusiastic and cooperative participation, the realization of the 1997 North American Conference on the Monarch Butterfly: Paper Presentations could never have been fulfilled.

Introducción

La monarca: oportunidad extraordinaria para trabajar juntos por la naturaleza

por ***Jürgen Hoth*** M.Sc.
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Tal vez ninguna otra especie de América del Norte ilustre mejor los retos de conservación de la naturaleza y desarrollo sustentable, en y entre los países, que la mariposa monarca.

La importancia de la cooperación internacional en la conservación del extraordinario fenómeno migratorio la subrayó en 1981 R. Pyle (1984). En sus conclusiones del Primer Simposio Internacional sobre la Biología y la Conservación de la Mariposa Monarca (Moncon-1), señaló que ninguna nación, de las tres que comparten la responsabilidad de conservar la migración, actualmente amenazada, de las mariposas monarca, podría hacerlo sola. Más aún, quienes participaron en esa conferencia lograron consenso en la definición de los principales desafíos para salvar a la mariposa: proteger los lugares en que sobrevive al invierno, además de atender otras necesidades ecológicas de la monarca, y encontrar fuentes de ingreso alternativas para los lugareños a fin de compensarles las pérdidas derivadas de los esfuerzos de conservación.

El creciente interés en la mariposa monarca y su también creciente importancia para la investigación biológica condujo en 1986 a la Moncon-2, el segundo simposio internacional dedicado a esas mariposas. En la reunión se destacó la relevancia de las monarca como modelo para una mayor comprensión de conceptos biológicos en campos que van desde la biología molecular hasta la evolución, pasando por su uso de las plantas, los movimientos migratorios, los sitios en que sobreviven al invierno y sus mecanismos de defensa (véase Malcolm y Zalucki, 1993a). Asimismo, numerosos artículos instaban a emprender esfuerzos de conservación, y otros fundamentaban la gravedad de la situación presentando los resultados de investigaciones realizadas para proteger a la mariposa, sobre todo en los lugares de México en donde invernan (Malcolm y Zalucki, 1993b).

Hacia finales del decenio de los ochenta, la conservación de la monarca había ganado presencia, como lo muestran las dos conferencias. En 1983, la Unión Internacional para la Conservación de la Naturaleza (UICN) declaró la emigración de la monarca como “un fenómeno amenazado” (UICN, 1983). En 1986, por decreto presidencial, en México se estableció la primera reserva de la mariposa monarca en América del Norte (*Diario Oficial de la Federación*, 1986; Ogarrio, 1993). Y en 1998, ciudadanos de California preocupados al respecto compraron un pedazo de tierra ocupada por una colonia en invernación a fin de asegurar su permanencia como reserva de la monarca (Allen y Snow, 1993).

Por una triste ironía de la vida, el decenio de los ochenta fue testigo también del peor ataque contra el fenómeno migratorio a todo lo largo de su campo de distribución en América del Norte; la causa principal: la destrucción del hábitat. Sólo en Estados Unidos, siete de los 45 sitios permanentes en que sobreviven al invierno se destruyeron a mediados de ese decenio. Los informes de ese periodo relacionaban la pérdida total de 21 sitios de la población occidental, destruidos sobre todo por la urbanización (Lane, 1984; Nagano en Malcolm, 1987; Sakai *et al.*, 1989, en Malcolm, 1993). Mientras tanto, en México se perdía uno de los cinco principales sitios de invernación de la población oriental, sobre todo a causa de la tala excesiva debida a la marginación y la falta de opciones económicas (Brower y Malcolm, 1989; Chapela y Barkin, 1995; Hoth, 1995; Martínez, 1995; Merino, 1997). Todas estas amenazas se identificaron desde la primera conferencia (Moncon-1), pero no trascendieron los círculos académicos ni se actuó en consecuencia.

Dieciséis años después de la primera conferencia y luego de diversas reuniones de conservación que marcaron hitos, como la Cumbre de la Tierra 1992, nuestro conocimiento de la conservación se ha enriquecido con conceptos como *desarrollo sustentable*, según lo manifiesta la Unión Internacional para la Conservación de la Naturaleza (1991; véase también Gauthier en este volumen). El conocimiento actual nos dice que para asegurar la conservación de cualquier especie es esencial hacer del desarrollo sustentable una realidad. Ello incluye no sólo asegurar la integridad medioambiental y la salud de los ecosistemas que albergan a determinadas especies, sino también abordar de manera eficaz las necesidades sociales y económicas de la gente que habita en el área protegida.

Ciertamente, ninguno de los sectores puede de manera aislada asegurar la conservación de la naturaleza o fomentar el desarrollo sustentable. La conservación es una tarea multidisciplinaria que si ha de rendir frutos requiere de la participación de la sociedad toda, tanto entre los países como en cada uno de éstos. Este reto social se puede abordar exclusivamente con la colaboración, la comunicación y la participación eficaces de los gobiernos, las ONG, los investigadores y las comunidades locales, y requiere el acceso a la mejor investigación científica y social disponible.

Considerando la oportunidad para asegurar la conservación de la mariposa monarca y sus jornadas migratorias en toda América del Norte, y en especial para buscar la participación de un amplio espectro de grupos de interés, la ciudad de Morelia, en el estado de Michoacán, México, fue sede de la Reunión de América del Norte sobre la Mariposa Monarca del 10 al 14 de noviembre de 1997.

La organizadora principal fue la Comisión para la Cooperación Ambiental, con la ayuda de otras doce instituciones: la organización campesina Alianza, el Comité Trilateral para la Conservación de la Vida Silvestre y los Ecosistemas, el Consejo Civil Mexicano para la Silvicultura Sustentable, la Embajada de México en Canadá, el Fondo Mundial de la Naturaleza (WWF), el Museo Canadiense de la Naturaleza, Parques y Vida Silvestre de Texas, la Secretaría de Medio Ambiente, Recursos Naturales y Pesca (Semarnap), el Servicio Canadiense de la Vida Silvestre (Environment Canada), el Servicio de Estados Unidos sobre la Pesca y la Vida Silvestre (Departamento del Interior), la Universidad Nacional Autónoma de México y la Universidad de Minnesota.

Con la meta de establecer una agenda de América del Norte para la conservación de la mariposa monarca, los objetivos principales de la reunión fueron: contribuir a la comprensión del fenómeno migratorio de la mariposa monarca y de los requerimientos para su conservación a lo largo de toda su ruta migratoria desde las perspectivas trinacional y multidisciplinaria; constituir un foro de diálogo entre personas, instituciones y grupos de Canadá, Estados Unidos y México interesados en la conservación de la mariposa monarca, y definir actividades conducentes a su conservación en un contexto de desarrollo sustentable.

Desde el principio de la reunión se destacaron los elevados costos sociales, económicos y políticos que entraña para México proteger las tierras de invernación de la mariposa monarca. Asimismo, se subrayó que era preciso que Canadá y Estados Unidos se unieran a los esfuerzos de México a fin de asegurar el futuro de esta especie y sus hábitats en toda América del Norte.

La conferencia gozó de un nutrido grupo de participantes: más de 300 personas, la mayoría de México, y otras provenientes de Australia, Canadá y Estados Unidos, incluidos representantes gubernamentales, indígenas, ONG y universidades. Fue lamentable la ausencia de dos grupos importantes: representantes del sector privado y las comunidades locales de Canadá y Estados Unidos.

Entre los resultados de esta conferencia destaca la publicación de dos volúmenes cuyos objetivos son ampliar la difusión de la información presentada durante el evento, así como apoyar y fomentar la participación de personas e instituciones en los esfuerzos de conservación de las mariposas monarca. Este volumen, *Reunión de América del Norte sobre la mariposa monarca, 1997*, presenta un panorama general de la investigación y los programas de conservación en curso, y pretende fundamentar y complementar las actividades aqui identificadas con las discusiones de la mesas redondas en las acciones prioritarias. El volumen II, ponencias, contiene los temas orientados a la acción que expresan las tareas más inmediatas requeridas para proteger a las monarca en toda América del Norte e identifica algunos de los principales agentes de este proceso.

Las áreas temáticas de la conferencia, como se aprecia en este volumen, atestiguan el nuevo enfoque más amplio y más rico de la conservación: la biología de la mariposa monarca (capítulo 1); la conservación (capítulo 2); la sustentabilidad y el desarrollo (capítulo 3), y la educación ambiental (capítulo 4). Más aún, las ponencias que fijaron la tónica incluidas en este volumen ofrecen una valiosa comprensión del futuro de las monarca. En representación de Estados Unidos, Lincoln Brower revisó la base biológica de fomentar la protección de los hábitats de invernación de México, con la autoridad obtenida de 21 años de experiencia en investigación. Carlos Toledo, que representó a México, describió las estrategias encabezadas por el gobierno para lograr la conservación de los sitios de invernación mediante políticas e iniciativas enmarcadas en un enfoque regional de desarrollo sustentable. Dave Gauthier, de Canadá, destacó la importancia de pensar en escala subcontinental al hablar de la sustentabilidad de los ecosistemas en cualquiera de los tres países de América del Norte.

Sin duda, esta reunión contribuyó a lograr una mejor comprensión de la situación actual de las monarca en toda América del Norte y a construir puentes entre grupos a menudo adversarios. Se sentaron las bases para fomentar la cooperación y el diálogo. Ahora depende de todos participar en los ámbitos locales, nacionales o internacionales para armonizar nuestros intereses y habilidades. Aparte del gusto de ver a las monarca revolotear en nuestros patios y saber que nuestros hijos se podrán regocijar al mirarlas en su ámbito silvestre, la recompensa radica en saber que si fue posible con la monarca será posible con otras especies, incluida la nuestra.

Introduction

The monarch: A regal opportunity for working together for nature

by ***Jürgen Hoth, M.Sc.***
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Probably no other species in North America better illustrates the challenges of nature conservation and sustainable development, among and within countries, than the monarch butterfly.

The importance of international cooperation for achieving conservation of the remarkable migration phenomenon has been highlighted in 1981 by R. Pyle (1984). In his concluding remarks at the First International Symposium on the Biology and Conservation of the Monarch Butterfly (Moncon-1) he stated that no one nation, of the three sharing responsibility for conserving the endangered migration of the monarch butterfly, could do it alone. Furthermore, participants in that conference reached consensus in identifying the main challenges to saving the monarch. These challenges were to protect Mexican and US overwintering sites and all other ecological needs of the monarch, and to find alternative sources of income for local inhabitants to compensate for loss of revenue related to conservation efforts.

Increasing interest in the monarch butterfly and its growing significance in biological research led in 1986 to Moncon-2, the second international symposium on the monarch butterfly. Contributions at this gathering emphasized the importance of the monarch as a model for advancing understanding of biological concepts in fields ranging from molecular biology to evolution, through the monarch's use of plants, migration, overwintering and defense mechanisms (see Malcolm and Zalucki 1993a). Additionally, several articles pleaded for conservation efforts to take place, and others substantiated the gravity of the situation by presenting the results of research carried out to protect the butterfly, primarily at the Mexican overwintering sites (Malcolm and Zalucki 1993b).

Towards the end of the 80s, monarch conservation had earned a high profile, as evidenced and spurred by both monarch conferences. In 1983, the International Union for the Conservation of Nature declared the migration of the monarch a "threatened phenomenon" (IUCN, 1983). In 1986, the Mexican government established by presidential decree the first monarch butterfly reserve in North America, (see Diario Oficial 1986; Ogarrio 1993). And in 1988, concerned citizens in California purchased a piece of land occupied by an overwintering colony to secure its future as a monarch reserve (Allen and Snow 1993).

As a sad irony, the 80s also witnessed the worst attack against the migration phenomenon throughout its distribution range in North America, the main culprit being habitat destruction. In the USA alone, seven of the 45 permanent overwintering sites were destroyed in the mid-80s. Reports in the late-80s informed of the overall loss of 21 overwintering sites for the Western population, destroyed primarily through land development (Lane 1984; Nagano in Malcolm 1987; Sakai et al. 1989 in Malcolm 1993). Meanwhile in Mexico, one of the five main Mexican overwintering sites of the eastern population was lost, primarily due to disenfranchisement and lack of economic alternatives (Brower and Malcolm 1989; Chapela and Barkin 1995; Hoth 1995; Martínez 1995; Merino 1997). All of these threats had been identified since Moncon-1 but, were neither heard beyond academic circles nor acted upon.

Sixteen years after the first monarch conference and after several milestone conservation meetings such as the 1992 Earth Summit, our understanding of conservation has been enriched by concepts such as sustainable development, as expressed by IUCN (1991; see also Gauthier, this volume). Current understanding suggests that a key aspect in ensuring the conservation of any species is to make the concept of sustainable development a reality. This not only includes securing the environmental integrity and health of the ecosystem harboring a particular species, but also effectively addressing the social and economic needs of the people living in the area to be protected.

Certainly, no one sector can secure nature conservation or foster sustainable development on its own. Conservation is a multidisciplinary undertaking that needs to be addressed by society-at-large, both among countries and within countries, if it is to be successful at all. This societal challenge can only be addressed through effective collaboration, communication and participation of governments, NGOs, academia and local communities, and requires access to, and support of, the best available scientific and social research.

Considering the opportunity to ensure the conservation of the monarch butterfly and its migration throughout North America, and especially to seek the participation of a wide spectrum of stakeholders, the city of Morelia, in the State of Michoacán, Mexico, hosted the "North American Conference on the Monarch Butterfly" (NACMB) from 10th to 14th November 1997.

The main organizer of this meeting was the Commission for Environmental Cooperation (CEC), assisted by twelve other institutions: Campesino Alliance (ALIANZA), the Canadian Museum of Nature, Canadian Wildlife Service (Environment Canada), the Mexican Embassy in Canada, the Mexican Civil Council for Sustainable Forestry, the Mexican Secretary for the Environment, Natural Resources and Fisheries (Semarnap), Texas Parks and Wildlife, Trilateral Committee for Wildlife and Ecosystem Conservation, *Universidad Nacional Autonoma de México* (UNAM), University of Minnesota, US Fish and Wildlife Service (Department of the Interior), and World Wildlife Fund (WWF).

With the goal of establishing a North American conservation agenda for the monarch butterfly, the main objectives of this meeting were: to contribute to the understanding of the migratory phenomenon of the monarch butterfly and of the requirements for its conservation along its entire migratory route, from tri-national and multidisciplinary perspectives; to provide a forum for dialogue among individuals, institutions and groups from Canada, the US and Mexico interested in conservation of the monarch butterfly; and to delineate actions conducive to conservation of the monarch butterfly in a sustainable development framework.

At the onset of the meeting, the high social, economic and political costs incurred by Mexico in protecting the monarch butterfly overwintering grounds was emphasized. The need for Canada and the US to join Mexican efforts in order to secure the future of this species and its habitat throughout North America was also stressed.

The conference benefited from a wide array of participants. More than 300 people participated, the majority from Mexico, others from the US, Canada and Australia, including individuals from indigenous communities, government representatives, NGOs and universities. Unfortunately, two main groups were missing: representatives from the private sector and from local communities from Canada and the USA.

Two volumes have resulted from this conference, with the goals of further disseminating the information presented during the conference, and supporting and encouraging individuals and institutions in monarch conservation efforts. The *1997 North American Conference on the Monarch Butterfly—Round Table Discussions and Priority Actions* features action-oriented issues, that express the most immediate undertakings required to protect the monarch butterfly throughout North America, and identifies several of the key players in this process. The volume which follows, *1997 North American Conference on the Monarch Butterfly, Paper Presentations,* offers an overview of ongoing research and conservation programs, and is meant to substantiate and complement the actions identified in the round table discussions and priority actions volume.

The theme areas of this conference, as expressed in this volume, bear witness to the wider and richer new approach to conservation: the biology of the monarch butterfly (chapter 1); conservation (chapter 2); sustainability and development (chapter 3); and environmental education (chapter 4). Moreover, the keynote lectures included in this volume provide precious insight into the future of the Monarch. Representing the USA, Lincoln Brower reviewed the biological basis for promoting the protection of the Mexican overwintering habitat, with the authority gained through 21 years of research experience. Representing Mexico, Carlos Toledo outlined the government-led strategy for achieving conservation of the Mexican overwintering sites through policies and initiatives framed within a regional sustainable development approach. Dave Gauthier, for Canada, stressed the importance of thinking on a continental scale when talking about ecosystem sustainability in any of the three North American countries.

Clearly, this meeting helped build better understanding of the current situation of the monarch throughout North America, and built bridges between often adversarial groups. Foundations were laid for promoting cooperation and dialogue. It is now up to all of us to get involved at the local, national or international level, in keeping with our interests and abilities. Apart from the joy of watching the monarchs fluttering in our backyards and knowing our children will be able to rejoice in watching them in the wild, the reward lies in knowing that if it was possible with the monarch, it will be possible with other species... including our own.

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Ponencias centrales
Keynote Addresses

Rosie Emery
“One of the things that Arne Naess said really moved me. He said ‘Deep Ecology recognizes that nothing short of total revolution in consciousness will be of lasting use in preserving the life support systems of our planet’.”

Steve Malcolm:
“A very large aspect of what we, scientists, do is to communicate. When we do research it’s never complete until it’s been communicated, until it’s been published, and we’re obviously failing dismally to communicate the results of our research. We’re communicating the results of our research in esoteric journals and are congratulating ourselves within our community that we’ve done fine work. But we’re obviously not making the most important leap of all, which is to communicate to *everybody* what’s important about this phenomenon.”

Manuel Sánchez García
“Nosotros, campesinos, estamos dispuestos a continuar el diálogo... queremos que la información que aquí estamos compartiendo se convierta en una realidad, no solamente en otra promesa.”

Biological necessities for monarch butterfly overwintering in relation to the Oyamel forest ecosystem in Mexico

by ***Lincoln P. Brower***
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University of Florida

Opening

First I should like to thank Secretary Julia Carabias of the Institute of National Ecology in Mexico, Secretary Bruce Babbitt of the Department of the Interior in the USA, and Karen Kraft of Environment Canada, in combination with the Commission for Environmental Cooperation of the North American Free Trade Agreement, for funding and attending this most important gathering of *ejidatarios*, scientists, citizens and other interested parties. One of our purposes this week is to have an open forum in which we can discuss the complex and difficult issues of preserving the high altitude Oyamel forest ecosystem that occurs in the Transverse Neovolcanic Mountain Range in the states of Michoacán and México. Doing this is of paramount importance because the migratory North American monarch butterfly is totally dependent upon these forests that serve as its overwintering habitat. I also thank Irene Pisanty and other members of the organizing committee for their dedication and effort in organizing the scientific, conservation, sociological, and economic aspects of our symposium. Most importantly, I thank the leaders of the several ejidos and indigenous communities for coming to this meeting to share their experiences and needs with all who are concerned about the future of the Oyamel forest ecosystem.

Before I begin my scientific review and present new data and hypotheses bearing on what I view as the imminent collapse of the eastern population of monarch butterflies in North America, I should like to share two personal experiences with the *ejidatarios* whose economic well-being is dependent upon the Oyamel forests. Juan de Jesús worked for me in the early 1980's when my students and I were conducting biological research in the monarch butterfly overwintering areas. In January 1981, we were camping in the Sierra Chincua at the head of Arroyo Zapatero near the butterflies at about 3,500 meters altitude. We had no idea how severe winter storms could be. On 13 January, a prolonged stormy period began with rain and hail, and by the 17th 7.5 centimeters of snow had fallen, followed by heavy snow over the next two days. On the morning of 19 January, we awoke to see over a foot of snow, collapsed tents and general chaos in our camp (Calvert, Zuchowski and Brower 1983). Our wood supply was low, and we were in a quandary on how to handle the situation. The next morning, having trudged through even deeper snow over the 3,400m Cerro el Mirador Pass (Anon 1987) to reach us, Juan and his son Evodio arrived at our campsite with their donkeys loaded with wood for us. Juan's knowledge and dedication saved our expedition. Then and there I learned how the forest and the people who know it intimately depend on wood from the forest. Juan subsequently worked for me for several winters before he died, and because of fond recollections I have of him and his family, I now dedicate this paper to his memory.

I, too, have experienced the anxieties of having my land expropriated. In the late 1960's when I was Professor of Biology at Amherst College, the United States government proposed a National Park in the Connecticut River Valley which would have taken my home and land away from my family. Faced with this difficult situation, a group of us organized and over two years we negotiated an agreement that not only protected us but also allowed planning of the Park to proceed. I learned from this trying experience that perseverance, honest negotiation, good arguments and a willingness to compromise could lead to agreements that would be fair to potentially affected individuals as well as promote the long-term common good. It is therefore with gratitude that I see so many of the *ejidatario* leaders here in this Morelia auditorium willing to exchange ideas and concerns.

Review of the spring and fall migrations of the monarch butterfly in North America

In North America, the monarch butterfly has two migratory populations, one that breeds west of the Rocky Mountains to the Pacific Ocean, and a second, much larger population, that breeds east of these mountains to the Atlantic Ocean. Figures 1 and 2 (from Brower 1995a) summarize our current knowledge of the locations of the breeding areas, the fall and spring migratory routes, and the overwintering areas for both the eastern and western populations in North America.

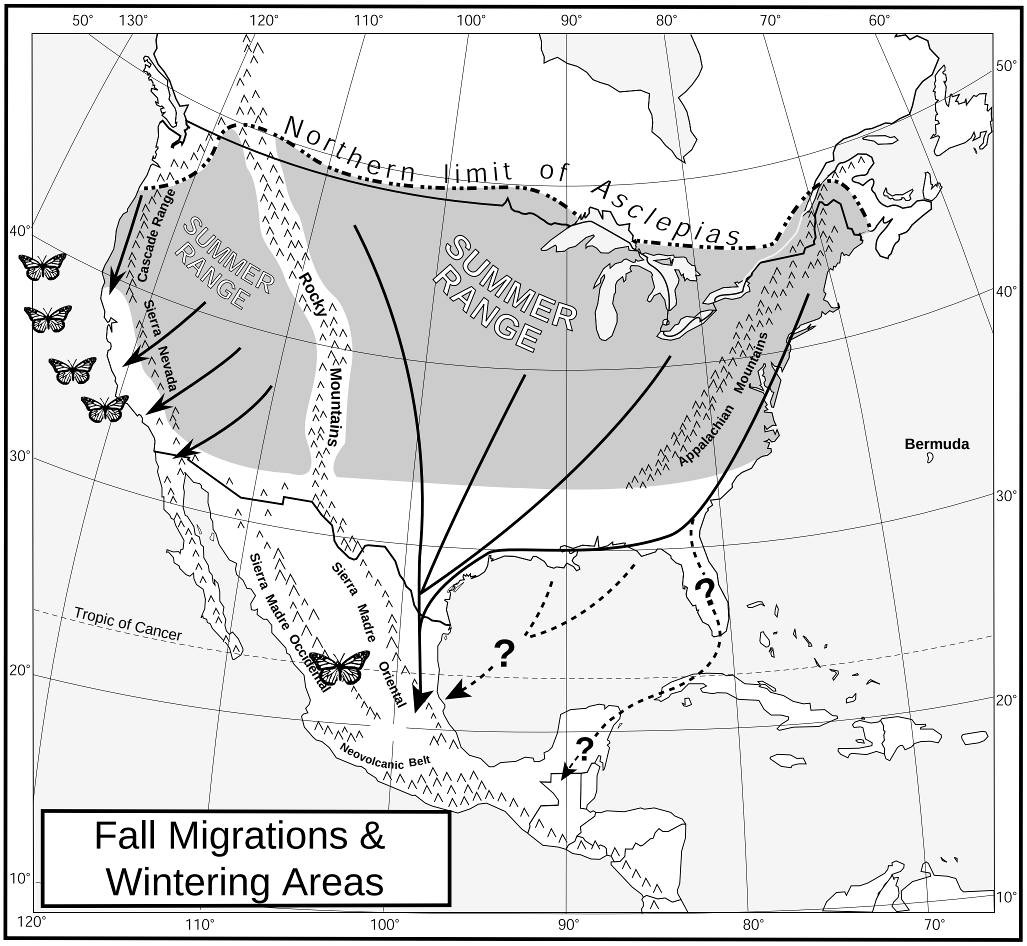

Figure 1. Fall migrations and overwintering sites of the two migratory populations of the monarch butterfly in North America. The *western population* breeds west of the Rocky Mountains during the spring and summer and migrates to numerous overwintering sites, mainly along the California coast, from north of San Francisco to south of Los Angeles. The second, much larger *eastern population* breeds east of the Rocky Mountains and migrates southwards to about thirty overwintering sites in the high peaks of the Transverse Neovolcanic Belt, south of the Tropic of Cancer in central Mexico. Migration across the Gulf of Mexico and Cuba remains hypothetical. (Reproduced from Brower 1995, with permission of The Lepidopterists' Society.)

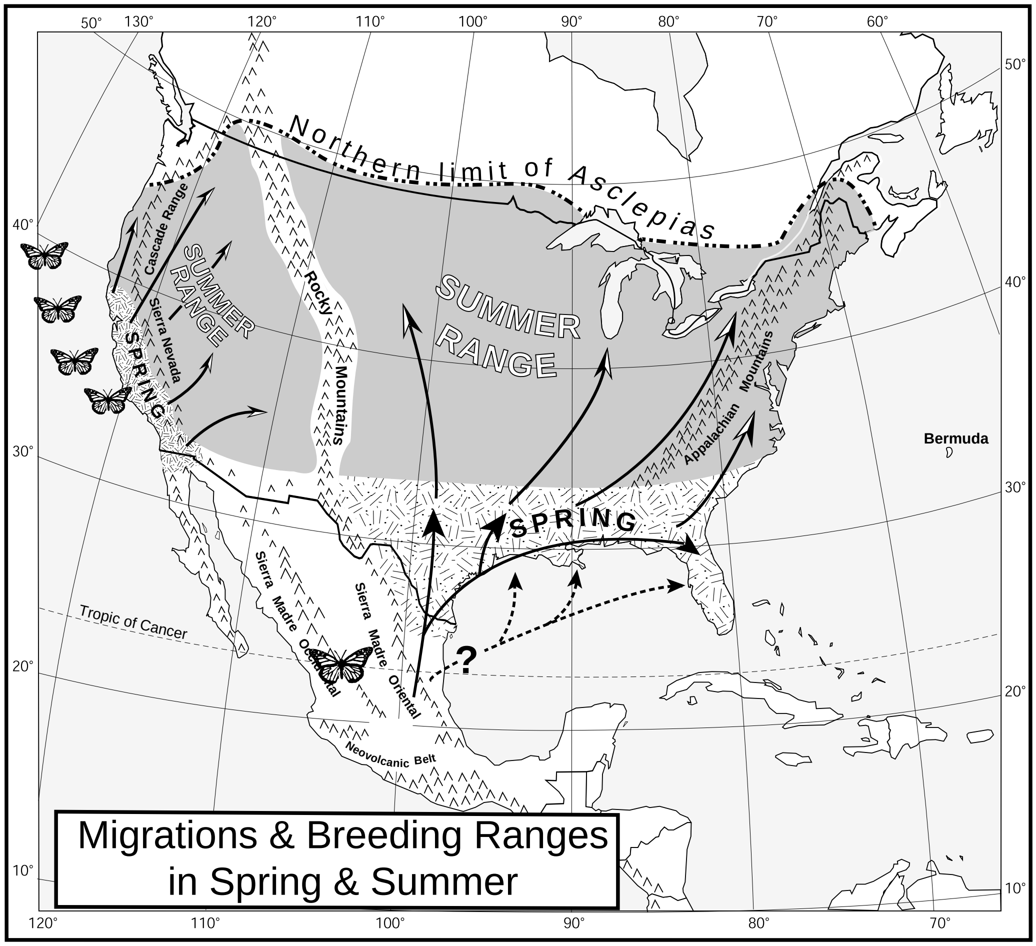

Figure 2. Spring remigrations of the monarch butterfly in North America. Overwintered individuals of the western population remigrate in early spring into the Coast Ranges, the Central Valley and the Sierra Nevada, where they lay their eggs on the resurgent milkweed flora and produce a spring generation. Monarchs that overwintered in Mexico remigrate at the end of March and early April to the Gulf Coast states, where they produce a new spring generation on the southern milkweeds. While a few of the overwintered monarchs probably migrate as far north as Canada, reestablishment of summer breeding northward to southern Canada is mainly by the large new generation produced in the south in April. Butterflies of this generation then fly northeastwards into the Great Lakes region, laying eggs along the migration routes. After the first spring and two or three subsequent summer generations, the monarchs enter reproductive diapause and begin migrating southward to their respective overwintering sites. Spring remigrations of the eastern population over the Gulf of Mexico and through Cuba are open to question. (Reproduced from Brower 1995, with permission of The Lepidopterists' Society.)

Each fall, monarchs that bred throughout the western range migrate southward and westward to numerous colonies along the Pacific coast of California. Because the overwintering sites are near sea level and sheltered by the coast ranges of California, the butterflies are protected from severe freezing. Those that survive the winter remigrate inland in the spring and establish a new generation. This new generation, in turn, is followed by several summer generations. By late August to early September, the annual cycle is completed, and the fall migration to the coastal overwintering sites is again underway.

The geographic location of the overwintering sites of the eastern population remained a mystery until January 1975 when two collaborators of scientists F. A. and N.R. Urquhart, Kenneth and Cathy Brugger, discovered a major overwintering area on Cerro Pelón, about 120 km west of Mexico City (Urquhart 1976; Urquhart and Urquhart 1976; Brower 1995a). Here, and at several other subsequently discovered overwintering sites in a remarkably small area of central Mexico (de la Maza-Elvira et al. 1977; Calvert and Brower 1986; de la Maza-Elvira and Calvert 1993), tens of millions of butterflies aggregate on trees at extremely high densities and constitute one of the most beautiful biological spectacles on our planet (Brower 1977, 1985a, 1985b, 1986, 1987, 1988).

Migrating from the eastern United States and Southern Canada during late August to November, the butterflies begin arriving at the Mexico overwintering sites in early November. Here they spend nearly five months. Then, at the end of March and in early April, the individual monarchs that survived the rigors of the high altitude winter rapidly leave the colonies and remigrate to the US Gulf coastal states. From Texas to Florida, they lay their eggs on various species of milkweed plants in the genus *Asclepias* (Asclepiadaceae) and establish the new spring generation. The freshly emerging adults of this spring generation then continue the migration northeastwards, principally to the Great Lake states and southern Canada, laying their eggs along the way (Malcolm, Cockrell and Brower 1993; Brower 1993; 1996b). Over the summer, two and possibly three more generations are produced in the northern range, and by late August the last generation is sexually repressed, the butterflies become highly social, and the fall migration to Mexico begins.

Characteristics of the overwintering area of the eastern population of monarch butterflies in Mexico

Following the initial discovery of the overwintering area of the eastern population, my colleagues, students and I conducted several expeditions to study the monarch's overwintering ecology in the states of Michoacán and México. Unlike the overwintering sites of the western population, which are at sea level along the California coast, the overwintering areas in Mexico occur above 3,000 m altitude in a forest dominated by the Oyamel fir, *Abies religiosa* (H.B.K.) Schl. & Cham. (Pinaceae). As summarized elsewhere (Brower 1995a), the Oyamel forest is part of a high altitude ecosystem that is limited to 13 vegetational islands on the higher peaks in Mexico, and occupies less than one half of one percent of Mexico's land area. Nine of these montane islands occur in the Transverse Neovolcanic Belt, a 50 to 100 km wide region of volcanic mountains and valleys that extends for 800 km across Mexico between latitudes 19ºN and 20ºN, and includes Mexico City. Extensive searching has determined that there are about thirty monarch butterfly colonies on nine separate mountain ranges. These mountain ranges occupy a very small area, approximately 30 by 60 km in extent (Calvert and Brower 1986). Thus monarchs which have bred in an area of more than 2.6 million km^2 east of the Rocky Mountains funnel into Mexico and concentrate in a geographic area of which only 161 km^2 are protected (Table 1). The densely aggregating butterflies in these and a few other nearby unprotected areas are, in effect, the seed crop which must survive the winter to be able to recolonize the eastern North American breeding range when spring and summer conditions return.

Table 1 Sizes of the breeding and protected overwintering areas[a] of the eastern population of the monarch butterfly in North America

Life History Phase	Hectares	Square Kilometers	Square Miles
Spring breeding in Southern USA[b]	87 million	.87 million	.33 million
Summer breeding in USA and Canada[b]	260 million	2.60 million	1 million
Overwintering areas, Mexico[c]	.0161 million[d]	.000161 million	.000062 million

Note: The breeding area is estimated from Figures 1 and 2 (from Brower 1995). Sizes of the overwintering areas in Mexico are from Anon (1986).

[a] The regional area where monarchs overwinter in the states of Michoacán and México is about 30 x 60km (Calvert and Brower 1986).

[b] Conservatively estimated from Figures 1A and B.

[c] These are the five areas protected by the 1986 Presidential Decree (*Diaro Oficial* 1986). They do not include several other known overwintering areas.

[d] Only 28% of the reserve area is totally protected in "nuclear zones". The "buffer zones" (62%) are inadequately protected and should be added to the nuclear zones.

The overwintering sites in Mexico occur in a rugged, beautiful and topographically complex region. The area contains hundreds of volcanic cones projecting from rich elevated valleys, including 13 of the highest peaks in Mexico, three of which exceed 3,650 m. The area originated during two periods of volcanism that accounted for most of the uplift as well as the volcanic peaks. The first period of volcanism occurred during the Miocene and affected all of Mexico, while the second began in the Pliocene and is still occurring. Because the Oyamel forest ecosystem's general appearance is like that of northern Canadian forests, it is referred to as a boreal forest ecosystem, according to Rzedowski (1978) and Manzanilla (1974), as summarized in Snook (1993, p. 365):

"Today's fir forests in Mexico are relicts of extensive boreal forests that advanced southward as the cold climates descended to tropical latitudes during the periods of glaciation. In the 10,000 years since the glaciers retreated, these forests have been displaced by temperate and tropical floras adapted to the warmer climatic conditions of today. Now only 40,000 to 50,000 hectares of fir forests remain in Mexico, distributed as isolated islands at elevations between 2,400 and 3,600 m, where the cold climate excludes most other genera and permits the firs to dominate. This reduced area and patchy distribution pattern make the fir forest perhaps the most vulnerable to deforestation pressures of any type of forest in Mexico."

The fir forest coincides with a summer fog belt and is damp, with mosses and lichens on the forest floor, and a rich herbaceous and shrub understory growing in partly opened areas beneath the forest. For a wealth of information on the vegetation associated with the monarch's overwintering areas in this Oyamel fir forest ecosystem, see Snook (1993) and Núñez and García (1993).

Survival of the monarchs from November through March in Mexico depends on a balance of macro and microclimatic factors resulting in weather that is: (1) cold enough to maintain the butterflies in a state of reproductive torpor, but not so cold as to kill them; (2) warm enough to maintain the integrity of their clusters, but not so warm as to result in excessive activity or premature gonadal maturation; and (3) wet enough to prevent desiccation and forest fires, but not so wet and cold as to preclude all activity (Brower 1985b; Masters et al. 1988; Calvert et al. 1989). Even though the overwintering areas occur south of the Tropic of Cancer, because they are at such high altitude, these Oyamel forests share many microclimatic characteristics with the coastal Monterey pine and *Eucalyptus* forests near sea-level in California where the western population overwinters (Leong 1990; Weiss et al. 1991).

Most importantly, the severe cold temperatures characteristic of the winter throughout the breeding range do not occur in either the Californian or the Mexican overwintering areas. However, the microclimatic conditions at the overwintering sites can be perilous to the butterflies, and this is especially so in Mexico for two reasons: (1) the thin air at the high altitude where the butterflies cluster allows severe radiant heat loss to occur; and (2) the orientation of the mountains in eastern North America allows cold arctic air masses to penetrate across the Tropic of Cancer. As a result, the Mexican overwintering sites provide a microclimate that allows overwintering, but only within a narrow range of conditions that depends on an intact Oyamel forest ecosystem

Migration and overwintering of the eastern North American population of the monarch butterfly is now an "endangered biological phenomenon"

Most conservation activities focus on the diminution of species diversity while largely ignoring a recent theme of equal importance: *endangered biological phenomena.* As defined in Brower and Malcolm (1991), endangered biological phenomena are particularly notable aspects of the life histories of animal or plant species involving a very large numbers of individuals: the species per se need not be in peril; rather, some spectacular phenomenon it exhibits is at stake. Examples include scores of current animal migrations that are being disrupted by accelerating habitat modification throughout the world (see also Brower 1997).

Monarch butterfly migration across the eastern United States and southeastern Canada and eastern Mexico, together with the extraordinary aggregations of up to tens of millions of individuals overwintering in the Oyamel forests of central Mexico, well exemplify the concept of an endangered biological phenomenon. Three factors are contributing to the endangerment: (1) the extensive use of agricultural herbicides throughout the Canadian and US breeding areas as well as along the migratory routes; (2) the extremely small area of Mexico in which monarchs overwinter; and (3) legal and illegal logging of the Oyamel forests in Mexico.

1. Herbicide use. During 1993 in the United States, an estimated 4.6 billion dollars was spent on 281 million kilograms of herbicide, and the use of these chemicals exceeded the combined use of all other insecticides, fungicides and other biocides (Aspelin 1994; Brower 1995a). The intended goal of herbicide use — now sprayed by over one million "certified applicators" in the USA alone — is to kill all competing plants over tens of millions of hectares of croplands.

Current research on the future uses of herbicides is even more insidious: genetically engineered crop species are being developed which are resistant to the herbicides (Sun 1986; Arntzen and Ritter 1994). From the perspective of monarch butterfly conservation, it should be noted that herbicides kill both the larval food-plants (mainly milkweeds in the genus *Asclepias*) and a plethora of adult nectar resources, including many species of fall blooming Compositae. Sugar derived from the nectar of these plants is critical for building up the butterflies' fuel reserves (lipids). These reserves enable monarch adults to migrate to Mexico, survive the long overwintering period, and then remigrate back to the United States.

The rapid evolution of herbicide technology and its burgeoning use is eliminating millions of hectares of larval and adult feeding habitats. Surely Rachel Carson would have been as alarmed by this development as she was about chemical insecticides in her classic book *Silent Spring*. Her warning about insecticides (1962, p. 22) is equally relevant to herbicide use today: "… we have put poisonous and biologically potent chemicals indiscriminately into the hands of people largely or wholly ignorant of their potentials for harm … Future generations are unlikely to condone our lack of prudent concern for the integrity of the natural world that supports all life."

2. *Tiny size of the Oyamel forest ecosystem in Mexico where monarchs overwinter.* Although herbicides are of major concern, comparison of the sizes of the breeding and overwintering areas (Table 1) compels me to conclude that the most pressing need is to focus on conserving the Oyamel forests. The spring breeding area in the southern United States covers about 87 *million* hectares and the summer breeding area across the United States and in southern Canada covers about 260 *million* hectares. In contrast, the five overwintering areas that are currently protected by presidential decree (Table 2) constitute a tiny area of only 16.1 *thousand* hectares. Another way of looking at this is that the currently protected overwintering areas are less than one hundredth of one per cent of the size of the summer breeding areas.

Table 2 **Areas of various national parks in the US compared with the monarch butterfly reserves in Mexico***

Five United States national parks

US National Park	Hectares	Square km	Square miles
Yellowstone, WY	898,785	8,988	3,469
Everglades, FL	566,168	5,662	2,185
Grand Teton, WY	124,491	1,245	481
Shenandoah, VA	79,079	791	305
Wind Cave, SD	11,451	115	44

* Presidential decree (Anon 1986).

Table 2 (cont.) **Areas of various national parks in the US compared with the monarch butterfly reserves in Mexico**

All Mexico butterfly reserves: core + buffer zones[a]			
Mexico Reserve[b]	**Hectares**	**Square km**	**Square miles**
Cerro Pelón	8,132	81	31.4
S. Chincua	2,696	27	10.4
S. Chivati-Huacal	2,014	20	7.8
S. Campanario	1,890	19	7.3
S. Altamirano	1,378	14	5.3
Total in Mexico[c]	16,110	161	62.2

Note: Areas of the five Mexico monarch butterfly reserves in the states of Michoacán and México compared to five United States National Parks selected to show a wide range of sizes.

[a] Logging is permitted in the buffer zones.

[b] S. Chivati-Huacal was clear cut in 1987 and burned in 1998. Other reserves are degrading due to deforestation on edges, illegal cutting in the buffer zones and illegal cutting by local residents.

[c] Core zones are 28% of (core + buffer zones); consequently *the totally protected area is only 17.4 sq. mi. (45 sq. km).*

To provide further perspective on the sizes of the current monarch reserves in Mexico, Table 2 compares their areas with five national parks in the United States, arranged from the largest (Yellowstone National Park) to one of the smallest (Wind Cave National Park). As shown in Table 2, note 4, the untenably small size of the monarch reserves is even smaller than it seems because only 28% of the total area within the five decreed monarch overwintering areas is completely protected.

Even if it were possible to provide permanent protection of these areas and the currently unprotected sites, the total area within the mountain ranges in which monarchs overwinter is still astonishingly small. Protection of all the known areas in which overwintering sites occur seems prudent to avoid unpredictable and random catastrophes including forest fires, volcanic eruptions, insect pests, tree parasites and diseases.

3. *Deterioration of the Oyamel forest ecosystem due to logging.* The Oyamel forests are the Achilles' heel of the eastern population of the monarch butterfly because they are rapidly deteriorating through legal and illegal logging activities (Snook 1993; Brower and Missrie 1998). As I have emphasized elsewhere (Brower, in press), Mexico needs a new perspective that aims at restoring and conserving the Oyamel forests *as intact ecosystems.* Such an ecosystem approach would automatically protect the flora and fauna of the areas, butterflies included, simultaneously protect the hydrological resources, and sustain the benefits of the forest for future generations. An overall plan that encompasses much larger areas than are currently protected, as well as protection of those sites not currently decreed as protected, is desperately needed in the immediate future.

Established and hypothesized negative effects of thinning the Oyamel forest

The rest of my paper provides an overview and summary of four well established and three hypothesized severe effects that thinning of the Oyamel forest has on the long term persistence of the monarch butterfly's migration and overwintering behavior in eastern North America. My hypotheses are based on experimental analyses and observations that I and my colleagues have made during all seasons over the past 21 years in the Mexico overwintering areas, as well as on general principles of insect physiology, and on direct observations made by the community of professional and amateur monarch researchers reported by two recent computer internet groups, *Journey North* (Donnelly 1997; 1998; Donnelly, this volume) and *Monarch Watch* (Taylor 1998; Taylor, this volume). I hasten to add that more scientific data are required to establish beyond reasonable doubt some of my predicted negative effects.

Established: Forest thinning increases freezing mortality of the overwintering butterflies

Anderson and Brower (1996) summarized prior research and provided new data on two major consequences for overwintering monarch butterflies of even moderate forest thinning (Table 3). The first point we have established is that the forest acts as a blanket: the intact canopy made by the spreading boughs of the firs above the butterflies reduces radiant heat loss on clear cold nights. Even small holes in the forest canopy—for instance resulting from the removal of a single tree—can cause the body temperatures of butterflies directly exposed to the night sky to fall several degrees below the ambient air temperature. This is because heat is radiated away from the bodies of the butterflies into space faster than they can receive it by convection, conduction and radiation from the surrounding air and vegetation (Geiger 1965).

Table 3	**Summary of the lethal thermal and wetting effects on monarch butterflies of thinning trees out of the overwintering colonies (the blanket and umbrella effects)**
A. Blanket effect of forest canopy (efecto de manta) Holes in the blanket increase radiant heat loss to sky when clearing occurs and... – butterflies' body temperatures fall below ambient, and – more butterflies freeze and die.	
B. Umbrella effect of forest canopy (efecto de sombrilla protector) Holes in umbrella increase wetting of butterflies during rain and snow storms and… – butterflies lose several degrees of cryoprotection, – ice crystals form on butterflies when clearing occurs, and – butterflies freeze to death.	

The second point is that the intact forest also serves as a partial umbrella that reduces the degree to which the butterflies become wetted during rain and snow storms. Openings in the forest allow more rain and snow to fall directly on the butterflies. In cold weather, water droplets on the surface of the monarchs freeze and the resulting ice crystals grow into the internal tissues with lethal effects. Anderson and Brower (1996) determined that even slightly wetted butterflies lose most of their natural antifreeze properties and freeze to death at body temperatures close to 0ºC, whereas dry butterflies survive temperatures that drop to below -8ºC. Making matters worse is the fact that wetting and exposure interact to result in much higher freezing mortality than would occur in an intact forest.

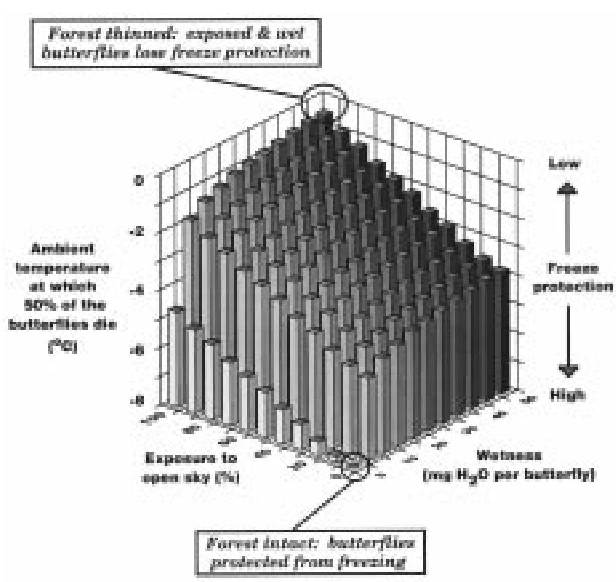

Figure 3. Surface wetting and increased exposure to the clear sky each increase the probability that individual monarch butterflies will freeze to death; this three dimensional figure shows their combined effects. The vertical axis indicates the air temperature at which 50% of a sample of butterflies will die. Dry, unexposed monarchs (at the bottom and front of the graph) tolerate the lowest ambient temperatures (50% die at -8.0ºC), while monarchs wetted with 50mg of water and with 100% exposure to the sky (at the top rear of the graph) can tolerate an ambient temperature of only about -1.4ºC, effectively losing 6.6ºC of their natural cryoprotection. The model shows that even moderate thinning of the Oyamel forest exacerbates monarch butterfly mortality caused by natural freezing at their high altitude overwintering sites in Mexico. (Reproduced from Anderson and Brower 1996, with permission of *Ecological Entomology*).

As summarized in Table 3, the extensive experimental studies of Anderson and Brower and other researchers in the Sierra Chincua overwintering area incontrovertibly indicate that forest thinning greatly increases butterfly wetting and heat loss. Other studies documenting the effects of forest thinning and freezing are in Calvert and Brower 1981; Calvert et al. 1982, 1983, and 1984; Calvert and Cohen 1983; Alonso et al. 1993; and Brower 1996a.

Established: Forest thinning increases wind velocity that dislodges butterflies, making them more subject to freezing

On days when the weather is overcast during the overwintering season, the ambient temperatures within the colonies fall below flight threshold for the monarchs (Masters et al. 1988). Moderate winds whip the branches that are laden with butterflies, blowing them out of their clusters onto the ground, while severe winds accompanying winter storms break off many of the butterfly-laden branches, spilling the butterflies over the ground by the thousands (Calvert et al. 1983, 1984). The body temperatures of butterflies on the ground during snow storms are also below the crawling threshold (Alonso et al. 1993). Such immobilized individuals are subject to severe wetting by rain and snow and totally lose their cryoprotection, as described above. The resulting higher mortality again subtracts monarchs from those able to perform the spring remigration.

Established: Forest thinning increases wind velocity that dislodges butterflies, making them subject to small mammal predation

At night, the immobilized butterflies, knocked down from their perches and scattered across the forest floor, are subjected to extensive predation by mice that live and breed in the forest both inside and adjacent to the colonies (Brower et al. 1985; Glendinning et al. 1988; Glendinning and Brower 1990). The resulting higher mortality from this factor subtracts yet again from numbers of monarchs able to perform the spring remigration (Table 4).

Table 4	Summary of the effects of forest thinning and increased wind velocities which blow the butterflies onto the ground
A. On cold days: 1. Immobilized butterflies on the ground are subject to wetting by rain and snow and then freezing.	
B. At night: 2. Immobilized butterflies are subject to small mammal predation.	
Ramification: Fewer monarchs remigrate north in spring.	

Hypothesized: Forest thinning increases wind velocity through the colonies and increases the rate of desiccation of the butterflies

No published data are yet available that bear directly on wind-caused desiccation of monarch butterflies within the overwintering colonies. However, I have on several occasions observed and photographed the effects on the butterflies of strong winds blowing through the severely thinned forest on the lower reaches of the Sierra Campanario overwintering colony above the town of Rosario. When this happens, the butterflies are buffeted about on the swinging branches and many are blown out of their clusters onto the understory vegetation and onto the ground. Insects in general are extremely subject to desiccation (review in Wigglesworth 1972; Hadley 1994) and this problem is exacerbated during windy periods when the humidity is low. Thus, from what we know of general insect physiology, combined with the specialized overwintering behavior of the monarchs inside the Oyamel forests, a cascade of negative effects, shown in Table 5, almost certainly results when the forest is thinned both adjacent to and within the overwintering colonies.

Table 5	Summary of the effects of forest thinning, which increases wind velocity through the colony, resulting in desiccation of the butterflies
Hypothesized cascading effects: 1. Monarchs forced to make more flights from shaded colony into sun to find and drink water. 2. Body temperatures rise in sunlight, gonadal maturation accelerates. 3. Monarchs leave colonies prematurely in March. 4. Monarchs arrive early in southern US and oviposit on delicate sprouting milkweed leaves. 5. Emergent milkweed leaves killed by frost. 6. First and 2nd instar larvae survive frost but starve to death on dry, crinkled leaves. 7. Remigrating monarchs continue northward: plants further north have not yet sprouted.	
Likely ramifications: a. Smaller numbers of adults produced in the new spring generation. b. Exponential summer recolonization and population growth diminished in the US and Canada. c. Fewer monarchs migrate in fall to Mexico.	

a. *First likely consequence of desiccation: increased flights to drink water.* Tens of thousands of monarchs fly out of the colonies on sunny days within a radius of about 1 km in order to drink water in open areas along streams, from dew-covered vegetation in clearings, and from water seeps (Calvert and Brower 1986; Masters et al. 1988; Brower 1996a). As the dry season progresses into February and March, the higher wind velocities and dry air blowing through the thinned forest will desiccate the butterflies more rapidly and thereby increase the frequencies of these rehydration flights.

b. *Second likely consequence of desiccation: increased rate of gonadal maturation and premature spring remigration.* As the butterflies fly out of the colony more frequently to rehydrate, they do so in direct sunlight and their body temperatures increase both from radiational warming in the sun and due to metabolic heat production during flight (Masters et al. 1988). One effect of these flights will be to speed up the rate of juvenile hormone secretion, which in turn accelerates gonadal maturation (Barker and Herman 1976; Herman 1986; James 1986). I hypothesize that this can cause the butterflies to exit the colonies on their northward remigration one to three weeks earlier in the season than they normally would do.

If in fact the monarchs leave the colonies prematurely, they will arrive in the southern United States in early to mid-March, rather than arriving as they normally do in late March to mid-April (Malcolm, Cockrell and Brower 1993; Cockrell, Malcolm and Brower 1993; Lynch and Martin 1993; Riley 1993). Based on my observations of sprouting *Asclepias humistrata* Walt. plants in north central Florida in March from 1981 through 1996, early arrival of the butterflies can have devastating consequences. First, they will have difficulty finding milkweeds because the plants will have just begun to reemerge as new shoots from the rootstock in the ground. Second, if the butterflies do lay eggs on the early sprouting milkweeds, the new leaves are subject to frost followed by rapid drying. While the frost may not be severe enough to kill the eggs or larvae, the withered leaves and young stems result in starvation of first and second instar larvae (Knight et al., submitted). Third, if the early arriving egg-laden females fail to encounter milkweeds sprouting in the Gulf Coast states from Texas to north Florida, they may keep migrating farther northward than normal. This, in turn, will exacerbate the problem because the farther north they fly so early in the spring, the less likely they are to encounter sprouting milkweeds.

Evidence for premature spring remigrations in 1997 and 1998

Several lines of evidence obtained during the springs of 1997 and 1998 indicated that monarchs may have left Mexico earlier than usual. First, many very early monarch sightings were reported well north of the Gulf Coasta states on the Journey North web site (Donnelly 1997) and the University of Kansas Monarch Watch web site (Taylor 1998). Additional support derives from John Fales' observations of monarchs made during April and May in eastern Maryland (Fig. 4). His data indicate a ten-fold increase in 1997 compared to the previous nine years' records.

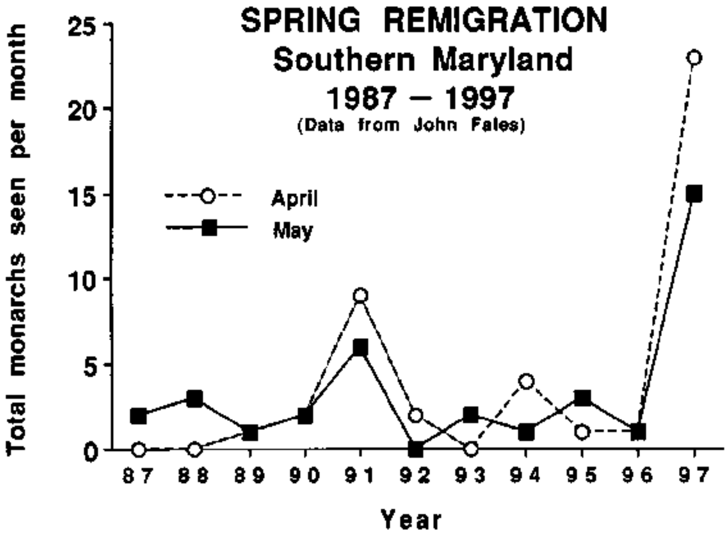

Figure 4. Spring remigration of the monarch butterfly during April and May 1987–1997 in eastern Maryland. The observations were made by Dr. John Fales and indicate that 1997 was an extraordinary year. Apparently, desiccation caused by thinning of the Oyamel forests in which the monarch butterflies overwinter in Mexico resulted in a premature spring remigration in 1997. The data, together with Malcolm et al.'s (1993) findings support the hypothesis that many of the remigrant butterflies from Mexico arrived along the Gulf Coast of the southern US prematurely and kept migrating northward in search of milkweeds upon which to lay their eggs (see Table 5 and text).

Brower also captured unusually high numbers of monarchs in the Blue Ridge Mountains in central Virginia between 5–18 May 1997. Thin layer chromatography analyses of these butterflies determined that 90% of 29 monarchs had fed on the northern milkweed *Asclepias syriaca* (Table 6). Based on the findings presented in Malcolm et al. (1993) and Brower (1993), these data indicate that these butterflies were not derived from the usual fresh spring generation of monarchs that bred in the southern coastal states, but rather were monarchs that had overwintered in Mexico. Further support that they were overwintered butterflies that had advanced farther northward than normal was their very worn condition compared to the far fresher state they would have been in had they been butterflies of the first spring generation produced along the Gulf Coast states (compare Figure 5 in this paper with Figure 7 in Malcolm et al. 1993).

Table 6 — **Summary of the results of thin layer chromatographic analyses of monarch butterflies collected in the Blue Ridge Mountains, Central Virginia, 5–18 May 1997**

Fed as larvae:	**Males**	**Females**	**Total**
On *Asclepias syriaca*	16	10	26 (90%)
Not on *A. syriaca*	0	1*	1
Pattern indistinct	1	1	2
Totals	17	12	29

* This female was fresh and had high lipid and lean masses and a high cardenolide content. Unlike the rest, it probably was a first spring generation butterfly that had fed as a larva on a toxic milkweed in the southern US. The data indicate that at least 90% of the butterflies were remigrants from Mexico that had flown much farther north than is typical (see text for further supporting evidence).

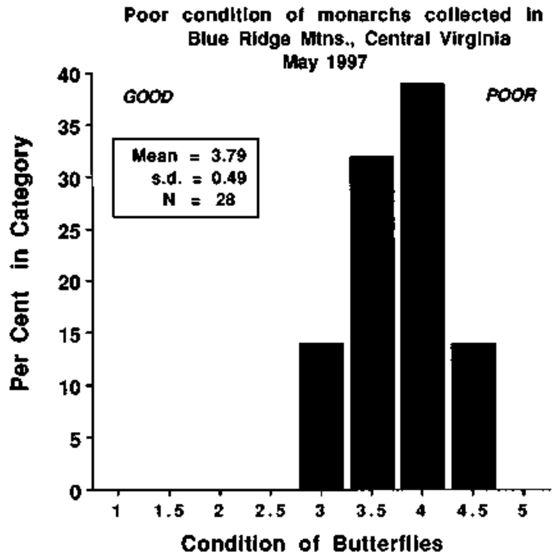

Figure 5. The premature arrival of remigrant monarchs in the central southern United States from Mexico as hypothesized in Figure 4 is supported by the generally poor quality of the butterflies collected in the Blue Ridge Mountains of Virginia in May 1997. Previous analyses (Malcolm et al., 1993) of monarchs collected during May and early June across the northern breeding range indicated much higher quality butterflies that had bred along the Gulf Coast rather than remigrating so far north from Mexico. See Table 4 and text for further evidence of a premature spring remigration in 1997.

Brower and Missrie (unpublished data) obtained evidence for the premature departure from the Sierra Campanario and Sierra Chincua overwintering sites in Mexico again in the spring of 1998, which I attribute to forest thinning greatly exacerbated by the severe drought conditions caused by the 1997–1998 El Niño season. Thus by 27 March 1998, the Sierra Chincua colony was virtually deserted, and on 31 March stragglers from mere remnants of the Sierra Campanario colony were observed migrating down slope through the town of Angangueo. Normally at this time, butterflies would still be flooding out of the mouths of both of these overwintering canyons (Calvert and Brower 1986 and unpublished observations, 1977–1998).

c. *Predicted consequences of premature spring remigrations.* If desiccation continues to increase as a result of the incessant thinning in the Oyamel forests, monarchs will continue to leave their overwintering colonies prematurely. As summarized in Table 5, I predict the following cascade of effects. First, fewer monarchs will succeed in establishing the spring generation along the Gulf Coast states and, as pointed out earlier, many individuals will fly futilely northward and be unable to reproduce successfully. This will result in fewer butterflies of the early summer generation in the north, particularly in the Great Lakes region and in southern Canada (see Figure 3 in Brower 1996b). Because of the eroded base of the normal exponential growth in the spring and first summer generations, the monarchs' usual one or two more summer generations in the north will also be diminished in numbers. As a consequence, fewer monarchs will be available to migrate southward to Mexico in the fall.

Hypothesized: Forest thinning leads to increased lipid consumption followed by starvation

As discussed above, increased wind velocity through the thinned forest must result in a higher desiccation rate so that the butterflies are forced on sunny days to make more frequent flights to water. While flying, the metabolic rate of the butterflies increases and they burn their stored lipids about 30 times as fast as individuals resting in the shade on the Oyamel boughs and tree trunks inside the colonies (Kammer 1970; Chaplin and Wells 1982; Table 2 in Masters et al. 1988).

Overwintering monarchs in Mexico that are low in lipid reserves fly out of the colony to locate flowers in order to obtain nectar. Masters et al. (1988) and Alonso-Mejia et al. (1997) determined that, on average, nectaring butterflies by January contain less than 30% of the lipid stores of butterflies resting on the branch clusters. They also found that the lipid stores in about 70% of the nectaring individuals were extremely low, i.e., feeding butterflies were on the verge of starvation. Exacerbating this problem is the fact that as the individual butterflies perch in the sun probing florets for nectar, their body temperatures rise dramatically. The direct effect of this heating is that the rate at which they burn their lipids also rises substantially (Masters et al. 1988).

Another problem with the increased wind velocity through thinned forests is that on overcast days the dislodged butterflies fall to the ground and then shiver to raise their thoracic temperatures to crawling and flight thresholds. As with flying, shivering is energetically expensive and also results in the butterflies burning their lipid stores about 30 times faster than when they are resting in the shaded clusters (Masters et al. 1988).

Established: Local flowers do not provide significant amounts of nectar for overwintering monarchs

Brower, O'Neil and Missrie (in prep.) determined during February and March of 1996 and 1997 that both the nectar and sugar contents of the majority of florets of several composite species near the colonies were extremely low, and many florets were totally empty. From our data we calculated that most of the monarchs nectaring in the sun actually burned more fuel and lost more water than they could gain.

Our findings are definitive evidence that refute Hoth's (1995) hypothesis that flowers in and adjacent to the overwintering colonies provide a significant sugar resource for the butterflies. Generalizing from this tenet, Hoth suggested that thinning of the forest could be beneficial to the butterflies by increasing the number of nectar sources. Aside from being refuted by our nectar study, Hoth's argument was based on unrealistic assumptions and an unjustified rejection of the published literature on lipid consumption in the monarch butterfly. For several criticisms of his hypothesis, see also Alonso et al. (1995), Brower (1995b), Calvert (1995) and Snook (1995).

More generally, no data-based studies to date have supported the hypothesis that thinning of the Oyamel forest can in any way be beneficial to the overwintering monarch butterflies.

Hypothesized: Overwintering monarchs with low lipid reserves suffer decreased fitness

Alonso et al.'s (1997) data provide strong support for the hypothesis that thinning the Oyamel forest in and adjacent to the butterfly colonies, with the resultant increased wind velocity, almost certainly has two major consequences in terms of the butterflies' lipid reserves. First, more butterflies must prematurely burn their lipid reserves to the point of starvation. Second, many butterflies that leave the overwintering sites on their spring remigration will do so with lipid reserves so low that it is unlikely that they can successfully remigrate to the southern United States and reestablish the new spring generation. The overall lipid consumption effects are summarized in Table 7.

Table 7	Forest thinning increases wind velocity through the monarch overwintering colonies Hypothesized effect: increases lipid consumption rate
A. On sunny days: 1. Monarchs forced to make more flights to rehydrate; rate of burning lipids increases ~ 30X. 2. Monarchs attracted to flowers to drink nectar; body temperature rises in sun: – forces further flights to water, – increases rate of lipid burning ~ 30X.	
B. On cloudy days: 3. Monarchs dislodged from clusters, fall to ground, *shiver* to raise body temperatures to flight threshold; lipid consumption increases ~ 25X. 4. Monarchs not reaching flight threshold crawl up on understory foliage; shivering syndrome repeated until increase in ambient temperature allows flight to rejoin clusters on Oyamels.	
Likely consequences of burning lipid reserves: a. Starvation at overwintering grounds. b. Insufficient fuel for spring remigration.	

Conclusions

Several lines of evidence backed up by extensive scientific findings published over 21 years and summarized in this paper lead me to the dismal prediction that if the Oyamel forests continue to be thinned, the eastern North American migratory and overwintering phenomena of the monarch butterfly will, within a few years, become extinct (see summary in Table 8). In addition to the documented microclimatological findings which support this prediction, I hypothesize several other detrimental factors resulting from forest thinning that lead to the same conclusion. These hypotheses are supported partly by fact, partly by well established general principles, and partly by logical extension of what is known. More research is needed on the cascading effects of desiccation and premature remigration in the spring as well as on lipid starvation.

Table 8	If the Oyamel Forests continue to be thinned…

1. The specialized microclimate provided by the Oyamel Forest will deteriorate.
2. Returning fall migrants will spend more time searching for less disturbed sites.
3. Survival rates of the overwintering monarch populations will drop.
4. Spring recolonization of the southern US will dwindle.
5. Negative climatic factors at the overwintering sites in Mexico by chance will be followed by extreme spring and summer climate in the southern US and Canada in the same year.
6. The fall migratory population collapses.
7. Overwintering in Mexico collapses.
8. The North American migratory phenomenon of the monarch butterfly becomes extinct.

Note: Predicted collapse scenario for the migration and overwintering phenomenon of the eastern migratory population of the monarch butterfly due to the accelerating logging, forest thinning and expanding agricultural activities in the states of Michoacán and México.

To prevent the loss of the migratory phenomenon of the monarch butterfly, far more extensive areas of the Oyamel forest need to be protected in the states of Michoacán and México. The boundaries of the protected areas need to be clearly marked; to date no markers exist delineating either the nuclear or the buffer zones. How can enforcement possibly occur under these lax circumstances? Current enforcement of the existing laws against cutting is haphazard, inadequate and often occurs only after illegal logging has taken place, when it is futile. The extent of permitted lumbering combined with the frequent inability to enforce laws against logging in and adjacent to the butterfly colonies is unacceptable if conservation of these Oyamel forest sanctuaries is to be effective.

The biological studies of the overwintering monarchs that I have summarized in this paper show definitively that the current Presidential Decree protecting five overwintering sites of the monarch butterfly in Mexico is inadequate. As I have pleaded elsewhere (Brower, in press), the time has come for a bold approach to restore and conserve the few remaining Oyamel forests of Mexico *as major intact ecosystems* which would automatically include permanent protection of the monarch butterflies.

If this approach fails, not only will the hydrological resources and therefore the local economies of the region eventually collapse, but the world community will be deprived of the extraordinary beauty and myriad scientific insights provided by one of the most magnificent natural phenomena on our planet.

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Estrategia integral para el desarrollo sustentable de la región de la mariposa monarca

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Desarrollo sustentable: conservación y bienestar social

Para México la región de la mariposa monarca es una zona prioritaria. Ubicada en territorio que abarca parte de los estados de México y Michoacán, es heredera de una gran tradición de años. Muchas de las palabras clave de los conflictos de la sustentabilidad se encuentran aquí expresadas. Se trata de una zona indígena pobre, con una vasta biodiversidad, y se considera región importante debido a que es uno de los sustentos del fenómeno natural de la migración de una especie que comparten los socios comerciales de América del Norte (Canadá, Estados Unidos y México). La región, por ello, está simbólicamente ligada al Tratado de Libre Comercio. Se trata de uno de los temas globales en donde existe interés de varias naciones y los ojos internacionales están puestos en esa región.

Por otra parte, la sociedad mexicana tiene múltiples expresiones de preocupación e interés por la situación de la zona, así como importantes demandas de las organizaciones sociales, comunitarias, no gubernamentales, grupos académicos y la ciudadanía. Todos maravillados por el fenómeno migratorio.

Las soluciones de fondo que se requieren suponen la conjunción de esfuerzos de todos esos actores, incluidos los tres niveles de gobierno, las instituciones académicas, las agencias internacionales y especialmente las comunidades indígenas y campesinas locales. Por ello el gobierno mexicano, a través de la Semarnap, convoca a la integración de todos los actores en torno a la misión común de hacer posible en esta región las tres dimensiones del desarrollo sustentable: primero, contener las tendencias de deterioro; segundo, fomentar una producción limpia y sustentable, y tercero, contribuir al desarrollo social y el combate a la pobreza, lo que se traducirá en un crecimiento económico que no afecte los recursos naturales y logre el beneficio de la población, de las generaciones presentes y futuras.

Este documento pretende ser la propuesta de un esquema integral articulador en torno a esos grandes objetivos del desarrollo sustentable, que abra espacios a las propuestas y planteamientos de los diferentes actores a fin de tener al alcance todos los puntos de vista, toda la información y todos los instrumentos para desarrollar las capacidades institucionales y sociales con las cuales enfrentar los problemas sobre conservación y desarrollo regional sustentable.

Se debe superar la idea de que nadie puede vivir en esta región porque tiene que conservarse a ultranza. Es inadecuada la conclusión de que se debe expulsar a sus habitantes. De la misma manera, es incorrecto el argumento que plantea que como hay pobreza y gente con raíces históricas y culturales, se puede hacer uso de los recursos sin cuidado de conservarlos. Se trata de generar alternativas que superen esta contradicción. La monarca y sus problemas no se restringen a las superficies de los santuarios, ni a las alternativas de manejo forestal dentro de estos sitios. En realidad se requiere de alternativas regionales para que la gente se beneficie del fenómeno migratorio.

La presente propuesta incluye un conjunto de datos técnicos sobre la biología de la mariposa monarca y el proceso migratorio. Posteriormente se aborda una descripción de las características de la región en sus dimensiones ecológico-geográfica, socioeconómica y productiva. En seguida se hace un recuento de los principales problemas y procesos y se describen los cinco programas propuestos. A continuación se refieren las alternativas organizativas para la conducción y coordinación de los programas, y finalmente se aborda la dimensión del compromiso internacional.

El fenómeno biológico

Clasificación taxonómica

La mariposa monarca es un insecto perteneciente al orden de los Lepidópteros, de la familia Nymphalidae, caracterizada porque en su metamorfosis, entre larva y crisálida o pupa, se fija a las ramas por una pequeña extremidad posterior, el cremáster, y en su fase adulta presenta una tendencia al atrofiamiento del par anterior de patas. Pertenece a la subfamilia Danainae, que en el hemisferio norte del continente americano está representada por once especies distribuidas en cuatro géneros.

Distribución

La especie *Danaus plexippus* es de amplia distribución en América. Se localiza desde el norte de Saskatchewan, en Canadá, hasta el sur de Perú. La población tipo, denominada *Danaus plexippus*, descrita por Linneo en 1758 fue colectada en Pennsylvania, Estados Unidos, y corresponde a la forma migratoria de América del Norte; para evitar confusiones se le nombra *Danaus plexippus plexippus* debido a que existen otras poblaciones similares.

En México se encuentran dos subespecies: la migratoria, *Danaus plexippus plexippus*, y la establecida, *Danaus plexippus curassavicae*. Aunque ambas parecen traslaparse en el centro del país, existen barreras etológicas que las separan, pues cuando entra el invierno y se forman las colonias de refugio de *Danaus plexippus plexippus*, entre los 2,400 y 3,100 metros de altitud, las poblaciones establecidas de *D. plexippus curassavicae* ya abandonaron las tierras altas y se ubicaron en la cuenca del río Balsas, entre los 1,000 y 1,700 msnm.

Ciclo de vida

El ciclo de vida de la mariposa monarca está dividido en fases, de formas físicas diferentes:

- *Fase de huevo.* Las hembras adultas identifican plantas del género Asclepias, y ovipositan en las hojas tiernas hasta 400 huevos. La larva eclosiona, en promedio, en tres a cuatro días.
- *Fase de larva u oruga.* La larva obtiene del envés de la hoja sustancias tóxicas (cardenólidos) que la protegen de los depredadores. La oruga tiene cinco estadios larvarios en dos a tres semanas; cuando alcanza su máximo crecimiento, se cuelga de una rama por el cremáster y forma la crisálida.
- *Fase de pupa o crisálida.* En un lapso de nueve a 15 días no realiza otra función que el intercambio gaseoso. Poco antes de surgir desarrolla una espiritrompa y la crisálida se torna oscura.
- *Fase adulta de mariposa o imago*. El tiempo total del desarrollo es de cuatro a cinco semanas. El periodo de vida de los adultos de invierno, que eclosionan en septiembre y principios de octubre, se eleva a seis o siete meses.

La estancia de las mariposas en los santuarios de los estados de México y Michoacán inicia los últimos días de octubre y dura hasta los primeros tres meses del siguiente año. Al elevarse la temperatura y ampliarse el fotoperiodo se aparean. Pasado el invierno e iniciada su fase reproductiva, la generación migratoria se dispersa en su regreso hacia el norte, ovipositando en la zona centro-sureste de Estados Unidos.

Las poblaciones de primavera pueden permanecer en estos sitios y originar otra generación o, dependiendo de la temperatura, continuar su viaje hacia el norte. Las hijas o las nietas de las invernantes darán lugar a tres o cuatro generaciones que se dispersan en la región noreste de Estados Unidos y en el sureste de Canadá.

Características de la generación migratoria

Migración. La reducción del fotoperiodo en las latitudes septentrionales, la presencia de masas de aire polar, y la escasez de néctar durante seis o siete meses son los factores que parecen desencadenar el fenómeno migratorio a través de tres rutas bien definidas (véase la gráfica 1):

1. Por el lado del océano Pacífico, las mariposas del sudoeste de Canadá y el noroeste de Estados Unidos viajan a California para agruparse en diferentes localidades a lo largo de la costa.
2. Sureste de Canadá y noreste de Estados Unidos, volando hacia Florida y atravesando Cuba y Yucatán; sin embargo, no se han localizado colonias de invernación en esta área.

3. Por el noreste de México, pasa por la Sierra Madre Oriental y las montañas bajas de San Luis Potosí, con dirección suroeste hacia los estados de México y Michoacán.

Las mariposas seleccionan las caras sur o suroeste de las montañas, tienden a situarse en las partes medias de los árboles, donde las temperaturas son más benignas, y se compactan para evitar la pérdida masiva de calor. Las poblaciones fluctúan entre siete y 20 millones de mariposas por refugio. A finales de febrero, las mariposas sexualmente maduras realizan el apareamiento. Conforme pasan los últimos días de febrero y los primeros de marzo, están aptas para regresar al norte.

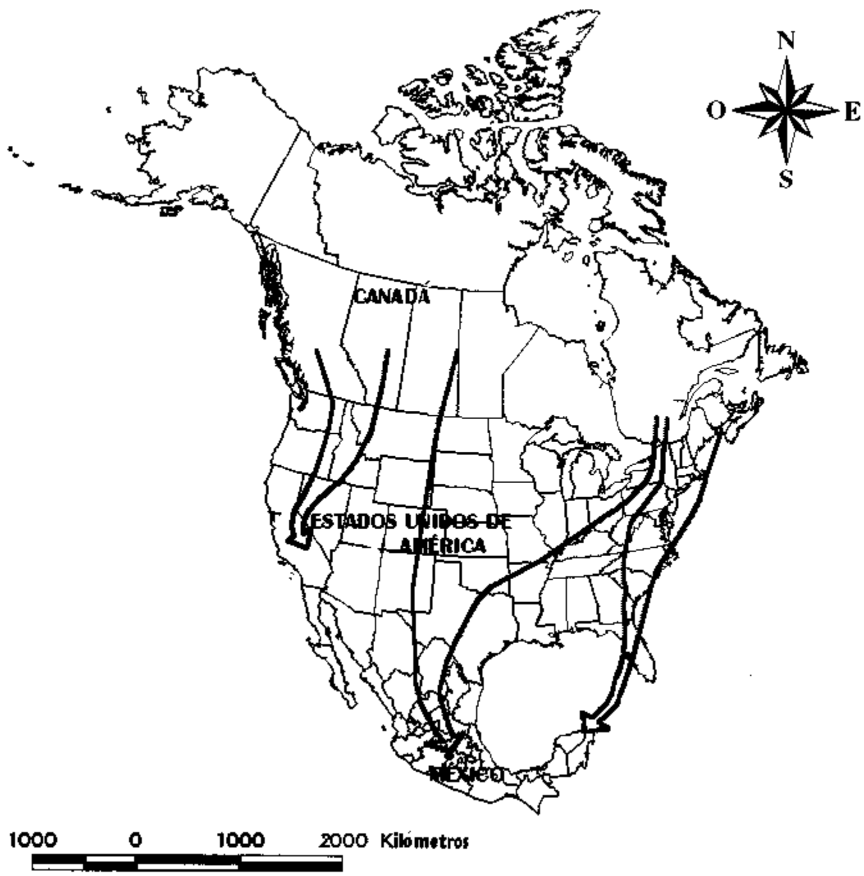


Figura 1: Mapa de rutas migratorias

Mortalidad. El porcentaje de mortalidad soportado normalmente por las poblaciones no se ha estimado con exactitud, aunque en situaciones excepcionales, como durante un fuerte norte, el daño es mayor. De las mariposas sanas que caen y permanecen al descubierto, aproximadamente 3% resultan muertas, 23% moribundas y 27% incapaces de retornar a los árboles.

Características de la región

Definición de la zona de atención y sus diferentes niveles

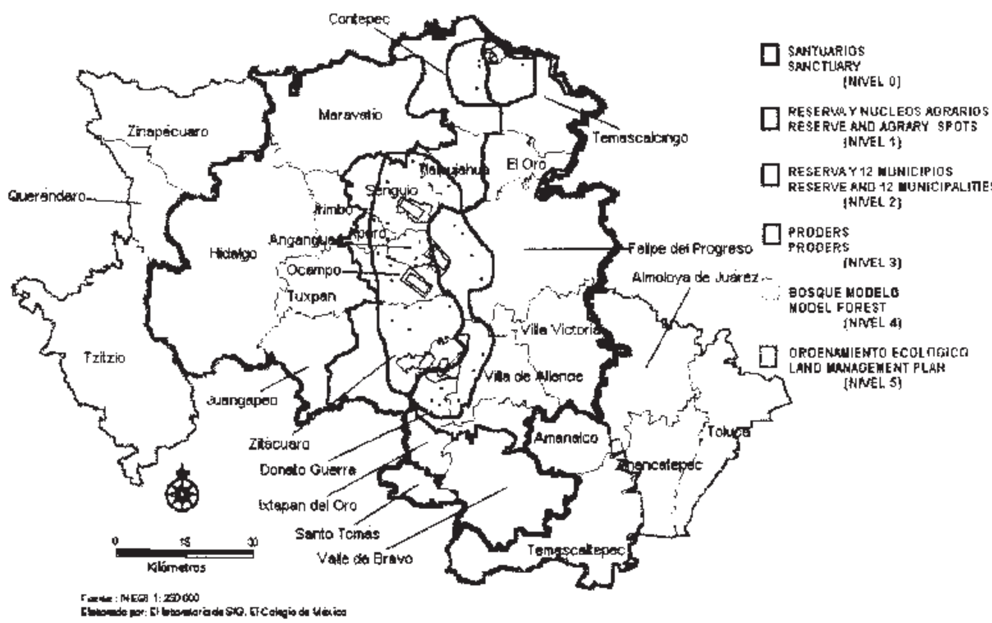
La región mariposa monarca constituye una frontera geopolítica y biogeográfica, en la cual se presentan fenómenos dispares de densidad poblacional, actividades productivas y presiones sobre los recursos naturales.

Por sus características geográficas es un área estratégica para la generación de bienes y servicios, como son la producción de agua y generación de aire. Gracias a sus bosques presenta un excelente potencial para la captura de carbono atmosférico y además por sus paisajes tiene posibilidad de crecimiento turístico. Su clima templado, suelos de origen volcánico e hidrografía rica en ríos, arroyos y manantiales generaron la presencia de masas de vegetación forestal y hábitats para numerosas especies de flora y fauna.

La región está definida como una articulación de las siguientes cinco escalas espaciales (véase la gráfica 2):

1. La zona de reserva, con 16,110 ha distribuidas discontinuamente en cinco áreas núcleo con una superficie de 4,488 ha, y 11,622 ha de zonas de amortiguamiento.
2. La reserva y los 54 núcleos agrarios que tienen territorio en los santuarios constituyen la entidad crítica de atención inmediata para la Semarnap. Aquí coinciden las acciones concretas que todos los programas realizan ya de manera prioritaria.
3. Los 12 municipios que tienen terrenos en la unidad anterior.
4. Los 22 municipios que conforman la región diagnosticada para el Programa de Desarrollo Regional Sustentable y los 23 para las del Bosque Modelo.
5. Los municipios integrados en el estudio del ordenamiento ecológico territorial.

Para los fines del presente documento, la descripción de la región mariposa monarca corresponde al nivel definido por el Programa Bosque Modelo y el Programa de Desarrollo Regional Sustentable (Proders) Mariposa Monarca.



Gráfica 2: Municipios de la región de la monarca

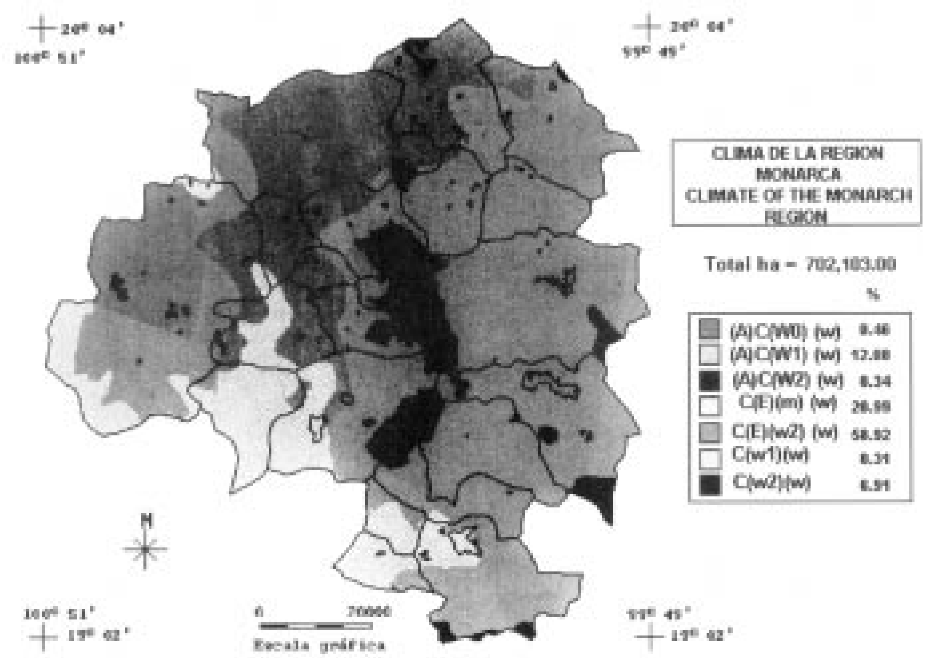
Descripción ambiental

La altitud del terreno oscila en un rango de 2,300 a 3,500 msnm. Por su ubicación de parteaguas, la zona forma parte de dos regiones hidrológicas: Lerma (RH12) al norte (41.75%) y Balsas (RH18) al sur (58.25%).

Su relieve está disectado por fuertes procesos tectónicos, lo que generó un terreno accidentado con diversas geoformas: sierras (51%), lomeríos (26%), valles (12%) y llanuras (6%). Casi la mitad de la región presenta una pendiente superior al 15%. Predominan los suelos andosoles (cerca del 43%), acrisoles (10%), planosoles (10%), feozem (8%), litosoles (7%), luvisoles (6%) y cambisol, regosol y vertisol (menos del 2%).

Clima

La presencia de montañas, sierras y relieves escarpados da lugar a contrastes en altitud, exposición y pendiente. Esto ocasiona a su vez variaciones en la temperatura, precipitación y humedad, al punto de que se registran temperaturas medias anuales de 8 a 22 ºC y precipitaciones anuales desde 700 hasta 1,250 mm. De acuerdo con la clasificación de Köppen, modificada por García, se presentan cinco subtipos climáticos (véase la gráfica 3):



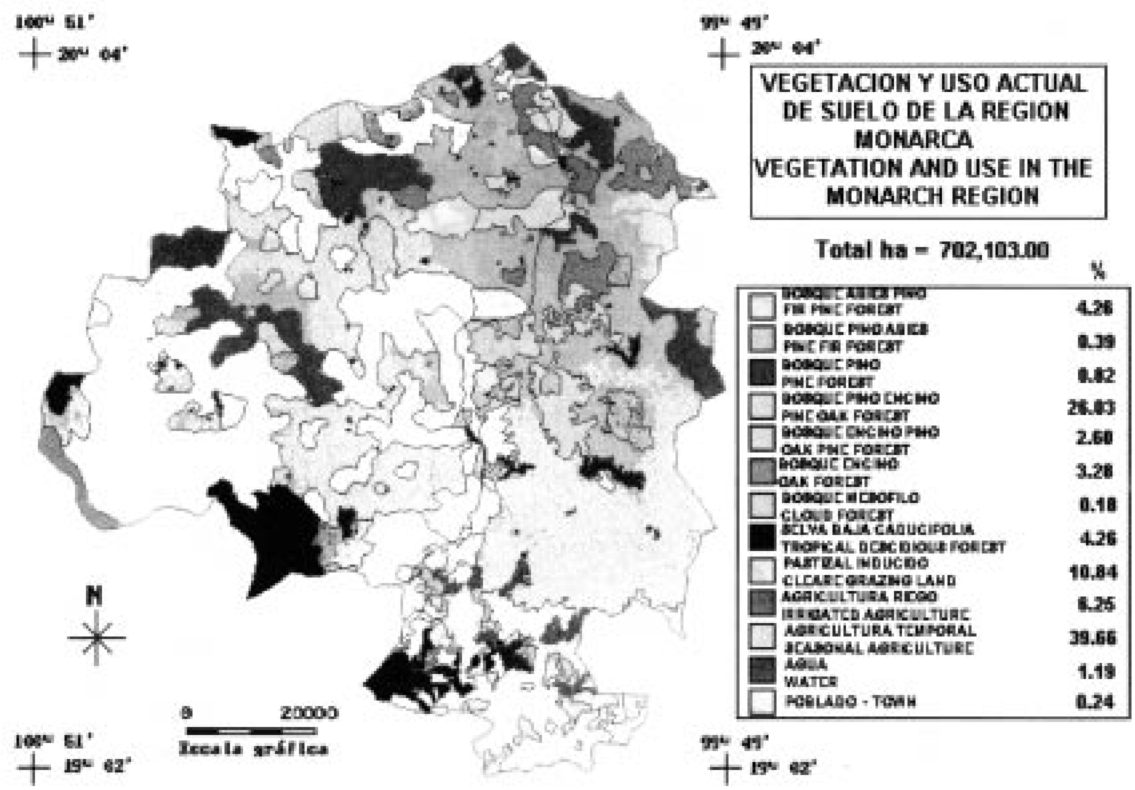
Gráfica 3: Mapa de clima

Cuadro 1	Tipos climáticos
(A) C w0	Semitemplado subhúmedo, el más seco
(A) C w1	Semitemplado subhúmedo, intermedio en humedad
(A) C w2	Semitemplado subhúmedo, el más húmedo
C w1	Templado subhúmedo, intermedio en humedad
Cw2	Templado subhúmedo, el más húmedo
C (E) w2	Semifrío subhúmedo, el más húmedo
C (E) m	Semifrío húmedo

Vegetación

La vegetación de la zona está constituida en un 22.81% por bosques (véase el cuadro 2) e incluye numerosos claros derivados de desmontes agrícolas abandonados, zonas de agostadero y establecimientos humanos temporales (véase la gráfica 4). La superficie de bosques explotables para madera es de 81,353 ha; de las cuales 54,456 se consideran comerciales y 26,897 no comerciales (1995). Dentro de esta superficie los claros por deforestación suman 12,310 hectáreas.

Cuadro 2	Vegetación
Tipo de vegetación arbórea	**Especies principales**
Bosque de abies-pino	-*Abies religiosa, Pinus pseudostrobus, Arbutus xalapensis, Alnus arguta, Clethra sp, Cleyera integripholia, Cornus disciflora y Quercus laurina*
Bosque de pino-abies	-*Pinus pseudostrobus, Abies religiosa P. douglasiana y Alnus arguta*
Bosque de pino-encino	-*Pinus douglasiana, P. montezumae, P. michoacana, P. oocarpa, Quercus obtusata, Q. resinosa, Q. laurina y Q. rugosa*
Bosque de encino-pino	-*Quercus rugosa, Q. obtusata, Q. crassifolia, Q. laurina, Pinus michoacana y P. douglasiana*
Bosque de encino	-*Quercus resinosa, Q. glaucoides, Q. deserticola, Q. obtusata, Q. castanea y Q. rugosa*
Selva baja y matorral	-*Bursera simaruba, B. cuneata, Lysiloma microphyllum, Leucaena*
Subtropical	-*Glauca, Pithecellobium dulce, Ipomoea murocoides y Opuntia spp*



Gráfica 4: Vegetación y uso actual

Vida silvestre

En general, la fauna silvestre es típica de las dos regiones biogeográficas de América del Norte (holártica y neotropical). Se calcula que en la región existen 15 familias de mamíferos con 54 especies; 31 familias de aves con 99 especies; anfibios, dos familias con 12 especies, y dos familias de reptiles con 17 especies. A grandes rasgos se estima la presencia de 184 especies de fauna.

Demografía

En los 22 municipios de la región, 914,516 habitantes viven en 1,643 localidades, con densidades de población por municipio que van desde 31 hab/km^2 (Aporo) hasta 219 hab/km^2 (Zitácuaro), lo que da un promedio ponderado de 115 hab/km^2 para la región, mayor a 2.5 veces la media nacional y el índice de crecimiento anual de la población es de 2.45% (2.39 para Michoacán y 2,52 para el estado de México). Del total de la población de la reserva, 99,390 habitantes, 79% (78,518 habitantes) se asienta en Michoacán y 21% (20,872) en el estado de México. De la población total, 7,438 habitantes hablan lenguas indígenas además de español (otomí, mazahua y náhuatl) y 108,481 personas mayores de 12 años son analfabetas.

Economía

La población económicamente activa es de 197,425. La mayoría de la población activa (41%) se dedica a actividades agropecuarias y forestales; el resto son obreros en pequeñas industrias, artesanos, comerciantes y algunos mineros. El ecoturismo en la región es una actividad económica en crecimiento.

La actividad agrícola más amplia es el cultivo del maíz; se cosecha también frijol, trigo, cebada, haba, tomate, alfalfa, papa, chícharo, maguey para pulque, chile manzano, frutales y flores. Por su gran potencial de desarrollo, debido a la creciente demanda, los cultivos que se comienza a impulsar son los huertos frutícolas, hongos comestibles, chile manzano, granada china y pérsimo.

La actividad pecuaria principal es la cría de ganado ovino, bovino, porcino, caprino, caballar, avícola, así como las actividades apícolas. Por otra parte, la acuacultura se ha incrementado en los últimos años, especialmente la cría de trucha.

Respecto a la actividad forestal, en el periodo 95-96 se autorizaron 369,281 m^3 de arbolado de pino, oyamel, encino y otras hojosas que proveerán de torcería larga, trocito corto y desperdicio de monte para material celulósico y leña.

La minería solía ser una actividad importante, pero actualmente se encuentra en decadencia por el agotamiento de las vetas.

Educación

De acuerdo con el INEGI, en 1995 la población mayor de 15 años sin primaria completa era del 50.31%, mientras que el analfabetismo alcanzaba 19.0%, es decir, 108,481 analfabetas. Una muestra de 42 localidades con población indígena en la región de la reserva nos revela indicadores preocupantes: el analfabetismo rebasa el 25% y aun alcanza máximos superiores al 60 por ciento.

Situación agraria

Se calcula que 35% de los ejidos y comunidades enfrenta conflictos de deslinde o problemas de certificación agraria; 91% de la tenencia de la tierra corresponde a propiedad social distribuida entre 54 núcleos agrarios, de los cuales 43 son ejidos, 11 comunidades, ocho pequeñas propiedades y dos terrenos nacionales: Chundua, un predio federal de 617 ha, y Monte Alto, predio estatal de 95 ha, ambos dentro del santuario Sierra Chincua.

La situación legal de los núcleos agrarios no presenta rezagos ni conflictos que los inhabiliten para emprender proyectos de desarrollo o inversión, con excepción de un litigio por predios en el santuario Cerro Pelón, entre el ejido Crescencio Morales y las comunidades San Pablo Malacatepec y Santa María (véase el cuadro 3).

Cuadro 3	Relación de ejidos y comunidades establecidos en la reserva			
Estado	**Municipio**	**Núcleo agrario**	**Tipo de propiedad**	**Situación jurídica**
México	Donato Guerra	El Capulín	Ejido	
		Mesas Altas de Xoconusco	Ejido	
		San Juan Xoconusco	Comunidad	
	San Felipe del Progreso	San Felipe de Jesús	Ejido	Sin Rezago
		Las Rosas-México	Ejido	Sin Rezago
		La Mesa	Ejido	Sin Rezago
		Rosa de Palo Amarillo	Ejido	Sin Rezago
		Buenavista (Casa Blanca)	Ejido	Sin Rezago
	Temascalcingo	Cerritos de Cárdenas Sección Gabino Vázquez	Ejido	Sin Rezago
		Pueblo Nuevo Solís	Ejido	Sin Rezago
	Villa de Allende	Vare (Varechiquichuca)	Ejido	
		San Pablo Malacatepec	Comunidad	
		Santa María y sus Barrios	Comunidad	
		San Jerónimo Totoltepec	Ejido	
Michoacán	Angangueo	Angangueo	Ejido	Sin Rezago
		Jesús de Nazareno	Ejido	Sin Rezago
		Santa Ana Dotación	Ejido	
		Hervidero y Plancha Ampliación	Ejido	
		Hervidero y Plancha Dotación	Ejido	
	Aporo	Arroyo Seco	Ejido	Sin Rezago
		Rincón de Soto	Ejido	Sin Rezago
	Contepec	Contepec	Ejido	Sin Rezago
		El Encino	Ejido	Sin Rezago
		Zaragoza	Ejido	Sin Rezago
		Santa María la Ahogada	Ejido	Sin Rezago
		San José Ixtapa	Ejido	

Cuadro 3 **Relación de ejidos y comunidades establecidos en la reserva**

Estado	Municipio	Núcleo agrario	Tipo de propiedad	Situación jurídica
	Ocampo	El Asoleadero	Ejido	
		Emiliano Zapata-San Juan	Ejido	Sin Rezago
		El Paso	Ejido	Sin Rezago
		Los Remedios	Ejido	Sin Rezago
		Ocampo	Ejido	Sin Rezago
		El Rosario	Ejido	Sin Rezago
		Cerro Prieto	Ejido	Sin Rezago
		Hervidero y Plancha	Ejido	Sin Rezago
		Santa Ana	Ejido	Sin Rezago
		San Cristóbal	Comunidad	Sin Rezago
	Senguio	Senguio	Ejido	Sin Rezago
		Chincua-Emiliano Zapata	Ejido	Sin Rezago
		El Calabozo	Ejido	Sin Rezago
		San Francisco de los Reyes	Ejido	Sin Rezago
	Tlalpujahua	San José de los Corrales	Ejido	Sin Rezago
	Zitácuaro	San Francisco Serrato	Comunidad	Sin Rezago
		Nicolás Romero	Ejido	Sin Rezago
		San Juan Zitácuaro	Ejido	Sin Rezago
		Aputzio de Juárez	Ejido	Sin Rezago
		Rincón de Ahorcados	Ejido	Sin Rezago
		San Miguel Chichimequillas	Ejido	Sin Rezago
		San Francisco Curungueo	Comunidad	Sin Rezago
		Donaciano Ojeda	Comunidad	Sin Rezago
		San Felipe los Alzati	Comunidad	Sin Rezago
		San Juan Zitácuaro	Comunidad	Sin Rezago
		Nicolás Romero	Comunidad	Sin Rezago
		Carpinteros	Comunidad	Sin Rezago
		Crescencio Morales	Ejido	Sin Rezago

Problemas fundamentales de la región

Los principales problemas y procesos de la región de la monarca responden en general a la contradicción entre la necesidad de conservar los recursos naturales, en particular el bosque, y la urgencia de aumentar los ingresos de corto plazo de la producción.

En términos generales, se identifican seis problemas fundamentales: deterioro en la calidad y cantidad de los recursos naturales; condiciones de marginalidad y pobreza que se viven en la región; ligado al anterior, una fuerte presión de la población hacia los recursos naturales; estancamiento en la producción de alimentos y bienes de consumo; necesidad de una mayor coordinación interinstitucional, y falta de participación de la población local y la sociedad en general en la gestión del desarrollo.

Estos problemas están relacionados con los siguientes factores que afectan la estructura regional:

a. En lo que respecta al deterioro de los recursos naturales, se tiene como proceso principal la deforestación. Este proceso se encuentra identificado como un eje fundamental que demanda la construcción de una estrategia. Para ello es necesario considerar el estado actual, la velocidad del proceso y los factores que lo están determinando. En el total de la región sólo alrededor del 30% está cubierto de vegetación, mientras que en los santuarios la superficie cubierta de vegetación es del 72% (véase la gráfica 4).

   Entre 1979 y 1994 el proceso de deforestación avanzó: la región perdió cada año 2,121 ha (0.66% anual), mientras que en la reserva la tasa anual de deforestación fue de 1.3%, esto es, 203 hectáreas por año.

   Los factores que influyen sobre la deforestación son principalmente tres: la necesidad de mayores ingresos económicos, las formas de manejo inadecuadas y la presión demográfica. Esta última se expresa en una densidad (115 hab/km^2) casi tres veces mayor que la media rural nacional.

b. Las condiciones de marginalidad y pobreza en la región están muy ligadas a la falta de una producción organizada y articulada al potencial ecogeográfico de la zona. De acuerdo con los indicadores del Consejo Nacional de Población, en la zona cercana a la reserva existen fuertes problemas de marginación social, ya que en 1980 se registró un índice de marginación de 0.8, si bien mejoró durante los diez años siguientes hasta llegar a 0.1 en 1990 —sin embargo, sigue en la categoría de alta marginación. Los principales puntos de atraso están representados por la mala calidad de vivienda (drenaje, piso de tierra, agua potable), analfabetismo, alto hacinamiento y deterioro del salario mínimo. La tendencia de estos indicadores señala que para el año 2010, con los medios y condiciones de ejecución actuales, la región apenas pasaría a la categoría de marginación media. Cabe señalar que la situación en la zona de la reserva es peor y que con las tasas de crecimiento poblacional presentes, los escenarios futuros son poco halagüeños.

c. En cuanto a las actividades económicas, de acuerdo con el valor de su producción, en la región la participación primordial es del sector agropecuario y forestal con 58.10% y le sigue el comercio con 15.90%; la aportación de los demás sectores es muy baja. Es importante señalar la alta proporción que representa la producción maicera en municipios como Contepec, Maravatío, Hidalgo, Valle de Bravo y San Felipe del Progreso, en donde se alcanzan rendimientos de 4 a 6 ton/ha, mientras que las zonas forestales tienen una baja producción en básicos. En las áreas cercanas a la reserva la actividad productiva es menor.

   Para enfrentar las tendencias mencionadas, se proponen las siguientes estrategias generales:

- Transformar estructuralmente el patrón de aprovechamiento de los recursos naturales, para mejorar sustancialmente la calidad de vida, especialmente la de la población cercana a la reserva, a través de una estrategia de manejo integral y sustentable de la naturaleza.
- Se requiere una mayor integración de las políticas de atención a la pobreza con los problemas ambientales y con el fomento productivo, y una coordinación adecuada entre las diversas acciones de construcción de infraestructura, productiva y ambiental.
- Finalmente, la sustentabilidad supone un involucramiento de la población local. Por lo tanto, es necesario instituir un esquema consolidado de gestión del desarrollo que permita alcanzar una planeación integrada, descentralizada, participativa y democrática.

Las propuestas de programas

En torno al objetivo general de impulsar un modelo de desarrollo sustentable en la región de la mariposa monarca, el gobierno mexicano ha propuesto, a través de la Semarnap, una estrategia integrada que utiliza diferentes herramientas generales de planeación descentralizada y democrática, todas articuladas por propósitos comunes de mediano y largo plazos.

Esta estrategia integral de atención a la región se compone de cinco programas:

1. El Ordenamiento Ecológico del Territorio.
2. El Programa de Manejo de la Reserva.
3. El Programa de Desarrollo Regional Sustentable.
4. El Programa del Bosque Modelo.
5. El Programa de Inspección y Vigilancia.

La integración de estos programas se fortalece a partir de los lineamientos que, en diferentes escalas y niveles, se desarrollan en el Ordenamiento Ecológico del Territorio.

Ordenamiento ecológico

El Ordenamiento Ecológico del Territorio (OET)[1] es el instrumento fundamental que la legislación ambiental establece para regular los usos del territorio y las actividades productivas, preservar y restaurar el equilibrio ecológico y proteger el ambiente (LGEEPA, 1988). En la región de la monarca, los estudios técnicos para la formulación del OET se realizan bajo la dirección de El Colegio de México.

En total se trata de 28 municipios: 11 en el estado de México y 17 en Michoacán.

Las fases de OET son: diagnóstico, pronóstico y propositiva, y actualmente presenta los siguientes avances:

- Un Sistema de Información Geográfica en escalas 1:250,000 y 1:50,000.
- Criterios para valorar, calificar y jerarquizar los cambios de la región durante 15 años.
- Identificación de zonas y procesos críticos resultantes de los cambios en el uso del suelo.
- Proyecciones de: a) comportamiento demográfico de las localidades, b) demanda de leña, c) demanda de alimentos, d) presión por tierras y e) disminución de superficies de bosques.
- Modelos donde se relacionan la dinámica social y los cambios del paisaje.
- Identificación de políticas para frenar procesos de deterioro y apoyar la conservación.
- Análisis del marco legal de las unidades de gestión, identificando estrategias y niveles de ejecución.
- Diseño de políticas por municipio y por niveles de deterioro ambiental y socioeconómico.
- Recomendaciones para el manejo sustentable de los recursos naturales por unidad de gestión.

Programa de manejo de la Reserva Especial de la Biosfera Mariposa Monarca

Los esfuerzos de conservación de la Reserva Especial de la Biosfera Mariposa Monarca se han visto incrementados gracias al apoyo otorgado por el Global Environmental Facility, derivado de la decisión de incluir esta reserva en el Proyecto de Conservación de la Biodiversidad en Áreas Naturales Selectas de México. La Dirección de la Reserva Mariposa Monarca[2] se ha dado a la tarea de diseñar, coordinar y ejecutar el Programa de Manejo de la Reserva, que tiene como objetivos:

- Garantizar la conservación de los bosques, así como las condiciones ambientales necesarias para la invernación, reproducción y ciclo migratorio de la mariposa monarca.
- Desarrollar en el área protegida acciones encaminadas a la restauración ecológica, protección, investigación, desarrollo sustentable, difusión, educación ambiental, capacitación y recreación.

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[1] El Colegio de México, "Ordenamiento ecológico territorial de la región mariposa monarca", documento en preparación y revisión por el Instituto Nacional de Ecología.

[2] Instituto Nacional de Ecología, "Programa de manejo de la Reserva de la Biosfera Mariposa Monarca", documento en preparación por la Dirección de la Reserva.

- Impulsar la participación organizada de las comunidades y ejidos que habitan en el área, así como la de los grupos académicos, organizaciones civiles y dependencias estatales y federales.

El programa de manejo tiene como principales estrategias:

- Atender microrregiones que se constituyan como un espacio de gestión del OET dentro de la reserva, en donde se articule el conocimiento técnico con el de las sociedades locales.
- Consolidar la identidad y el patrimonio cultural de la región mediante el impulso de circuitos de comunicación alternativa, un sistema de información básica y un centro de documentación.
- Constituir una coordinación de investigación que apoye las actividades científicas en la zona.
- Generar mecanismos de identificación de alternativas productivas.
- Impulsar la transferencia de tecnologías que garanticen procesos productivos sustentables.
- Promover al Consejo Técnico Asesor (CTA) como un órgano que apruebe y evalúe el Programa de Manejo y los Programas Operativos Anuales de la Reserva.
- Consolidar al Grupo Operativo Mariposa Monarca (GOMM) como una instancia que busca fortalecer la capacidad de coordinación operativa de las áreas de la Secretaría involucradas en la región.

La Dirección de la Reserva cuenta ya con una propuesta de programa de manejo que ha empezado a discutirse entre diferentes actores regionales, así como el desarrollo de acciones para constituir el CTA.

Programa de Desarrollo Regional Sustentable

Con la intención de impulsar políticas y acciones que permitan incorporar a municipios, dependencias y diversos actores sociales, políticos y económicos, en la concertación de tareas dirigidas hacia un desarrollo sustentable, se ha propuesto el diseño, operación y evaluación del Programa de Desarrollo Regional Sustentable (Proders), con los siguientes objetivos:

1. Impulsar un desarrollo económico que permita satisfacer las necesidades humanas y elevar los niveles de vida y, al mismo tiempo, mantener la cantidad y calidad de los recursos naturales.
2. Incorporar a la población local en la planeación de acciones y proyectos comunitarios, en donde se considere el corto, mediano y largo plazos.
3. Generar la capacitación y conocimiento de los habitantes sobre el potencial de sus recursos naturales y alternativas de desarrollo.
4. Apoyar mecanismos que permitan cambiar la manera en que se planea y evalúa el desarrollo regional, generando instrumentos para una planeación adecuada y propiciando la incorporación de los actores regionales.
5. Articular los procesos productivos regionales y locales con la economía nacional e internacional.

El Proders se ha propuesto, con base en dos líneas de trabajo, el diseño técnico del programa y su discusión por los diversos actores regionales, así como la atención en dos escalas: la regional y la comunitaria.

La parte técnica del programa, en la región y en cinco comunidades piloto, ha estado a cargo del Instituto de Investigaciones Agropecuarias y Forestales (INIFAP), que ha desarrollado un diagnóstico natural y socioeconómico.

Las estrategias propuestas por el INIFAP son las siguientes:

- Generación de proyectos subregionales que se inserten en los programas municipales, con énfasis en la conservación y la capacidad turística del área.
- Desarrollo de un esquema de educación, capacitación y transferencia de tecnología sustentable.
- Definición, concertación y gestión de las políticas a corto, mediano y largo plazos.
- Apoyo de regiones lejanas que se benefician de los recursos de la región.

[3] Instituto Nacional de Investigación Agropecuaria y Forestal, Programa de Desarrollo Regional Sustentable, documento en preparación. Próximamente se iniciará el proceso de discusión con los diferentes actores regionales.

- Concentración de esfuerzos en comunidades piloto para realizar un proceso de transformación en el marco del microdesarrollo.
- Integración de un sistema de información para el desarrollo regional sustentable.
- Impulsos para la formación de Consejos de Desarrollo Regional (CDR).

Se propone la estructuración de un sistema articulado de subprogramas dentro de los cuales se encuentran los siguientes: nutrición, salud y agua para consumo humano; educación ambiental; caminos; manejo de bosques locales, reservas ecológicas y fauna silvestre; producción no maderable; captura de carbono; agroforestería y manejo de zonas de ladera; uso de minerales de alta retención y derivados orgánicos; producción de traspatio; fruticultura; producción piscícola y ganado en estabulación; turismo y recreación; promoción cultural; industria forestal y de transformación.

Por otra parte, se están ejecutando proyectos y acciones en diez localidades piloto en los rubros de acuacultura, conservación de suelos, manejo forestal, aprovechamiento de fauna silvestre y agroforestería.

La discusión del programa y el desarrollo de proyectos se acompañan de actividades de capacitación y de fortalecimiento de las comunidades y la sociedad civil.

Bosque Modelo

El Programa de Bosque Modelo Mariposa Monarca que es parte de las actividades de cooperación entre los gobiernos de México y Canadá, busca articular un esquema de interrelación de los actores regionales y la cooperación internacional para impulsar el uso racional de los bosques.

Para Bosque Modelo es importante proteger y conservar las áreas de influencia de la mariposa monarca, por el significado que tiene la sobrevivencia de esta especie.

Los objetivos generales del Bosque Modelo Mariposa Monarca son:

- Mejorar el nivel de vida de los pobladores y fortalecer la economía de la región.
- Lograr el aprovechamiento sustentable de los recursos forestales.
- Impulsar la inversión privada y fortalecer la participación social.
- Coadyuvar en la conservación del hábitat de la mariposa monarca.
- Proyectar la región hacia el ámbito internacional.

Las principales líneas estratégicas son:

Participación comunitaria

- Sustentar, a partir de los acuerdos locales, las estrategias, programas y proyectos para el desarrollo.
- Articular los requerimientos para el bienestar social con las propuestas de desarrollo económico.
- Impulsar la participación de los municipios de la región mediante la creación de espacios.
- Promover la educación ambiental pública.
- Establecer el marco general para el fomento y difusión cultural en la región.

Proyectos productivos

- Impulsar actividades productivas, preferentemente en el sector forestal.
- Impulsar la consolidación de la infraestructura básica, social y productiva, de la región.
- Impulsar proyectos productivos del sector agropecuario, así como de ecoturismo.

Investigación aplicada y transferencia de tecnología

- Impulsar la transferencia y utilización de sistemas de producción más eficientes y rentables, así como de mejores tecnologías que permitan un uso racional de los recursos naturales.

Estrategias de planeación.

- Impulsar un sistema de planeación regional con los pobladores y el OET como instrumento principal.

Estrategias forestales

- Impulsar la reactivación del desarrollo económico del sector forestal.

- Impulsar la participación de los habitantes en las tareas de protección y fomento de los recursos.
- Fomentar el equilibrio entre las actividades de conservación y las del aprovechamiento.
- Impulsar los proyectos de plantaciones forestales comerciales y de otras especies forestales.

Programa de inspección y vigilancia

Desde 1992 en la Reserva Especial de la Biosfera Mariposa Monarca se han realizado acciones de protección que incluyen la inspección y vigilancia por parte de la Procuraduría Federal de Protección al Ambiente (Profepa); sin embargo, hasta 1997 no se inicia la aplicación de una estrategia integral mediante la aplicación del Sistema de Protección Estratégico Dirigido (SPED), que ha ofrecido resultados contundentes en la disminución de ilícitos.

El programa contempla el establecimiento de comités sociales de vigilancia como una instancia de corresponsabilidad entre la población local y la Profepa para prevenir e identificar ilícitos.

Durante 1996 y 1997 se realizaron las siguientes acciones operativas de inspección y vigilancia.

- 546 ondas sistemáticas de vigilancia
- 173 inspecciones y verificaciones
- 309 dictámenes
- 210 recomendaciones expedidas
- 104 actas administrativas
- 132 presentaciones de infractores a las autoridades
- 56 formaciones de comités de vigilancia participativa
- 538 asambleas y reuniones
- 63 operativos especiales

Organismos para la conducción concertada del desarrollo sustentable

Una condición básica del éxito en el impulso a las alternativas de desarrollo sustentable en la región es la plena apertura a la participación social y académica, así como la adecuada coordinación e integración de las diferentes instituciones del gobierno nacional y también de las agencias internacionales.

La estrategia de conservación con desarrollo social y económico requiere de la suma de todos en espacios de concertación en los que las diferencias sean discutidas y encauzadas en la perspectiva de objetivos comunes y acuerdos de mediano y largo plazo que sinteticen la diversidad.

Por ello, además de diagnosticar los problemas, definir estrategias y acciones, todos los actores regionales buscan los consensos y acuerdos estratégicos que sean los ejes de sus esfuerzos. También es fundamental que esos acuerdos sean base para constituir organismos de coordinación, participación y consulta que permitan una planeación, conducción y evaluación del desarrollo sustentable descentralizada, participativa, integral y democrática.

Estos organismos deben ser inclusivos y plurales, y contar con una efectiva capacidad de decisión. Deben ser el espacio en donde se aprueben los objetivos y estrategias básicas, a la vez que los sujetos encargados de definir y evaluar conjuntamente las acciones y proyectos.

Para lograr este esquema de planeación se construye un conjunto de organismos con esas características, asociados a la ejecución de los programas específicos; estos organismos son:

- El Consejo Técnico Asesor de la Reserva.
- Los Consejos de Desarrollo Regional Sustentable.
- El Consejo Directivo del Bosque Modelo.
- Los Comités Sociales de Vigilancia.

Consejo Técnico Asesor

Es el órgano encargado de realizar las consultas intersectoriales para el diseño consensado de las mejores acciones sociales y gubernamentales en la conservación y manejo apropiado de los recursos naturales, así como para mejorar la calidad de vida de las comunidades y ejidos por la vía del desarrollo sustentable. Le corresponde conocer, aprobar y evaluar el Programa de Manejo y los Programas Anuales Operativos; opinar sobre otros instrumentos de acción institucional que por sus acciones apoyen o pongan en riesgo las estrategias comúnmente acordadas para la conservación y el desarrollo sustentable. Una atribución del Consejo es vigilar el manejo honesto y transparente de los recursos financieros que se apliquen en la reserva, y, por último, ser corresponsable en la gestión de los apoyos complementarios.

Para constituirlo se han realizado consultas con los diferentes actores locales y regionales. Se establecieron compromisos de participación que involucran a:

- Representantes de núcleos agrarios.
- Organizaciones sociales más representativas en la región.
- Organizaciones no gubernamentales.
- Fondos regionales para el desarrollo de los pueblos indios.
- Académicos destacados.
- Presidentes municipales.
- El director ejecutivo del programa Bosque Modelo.
- La Dirección de la Reserva.

Consejos de Desarrollo Regional Sustentable

Los consejos pretenden: 1) la coordinación intergubernamental; 2) la participación plena de comunidades, organizaciones sociales y ONG, y 3) la articulación e integración de la inversión en acciones y proyectos de desarrollo (Programas de Inversión Regional anuales). La primera tarea que deben desarrollar, y que incluso constituye un proceso paralelo a su construcción, es la discusión, consenso y aprobación del Programa de Desarrollo Regional Sustentable. Como tareas permanentes, los consejos deben instrumentar el proceso de programación, presupuestación, seguimiento y evaluación de las acciones operativas anuales y cuidar su coherencia estrecha con las estrategias y líneas de acción señaladas en el Programa de Desarrollo

Ya que la región de la monarca abarca territorios del estado de México y de Michoacán, se plantea la construcción de dos consejos, uno para cada una de las entidades federativas. Su posible constitución se basa en el marco de las leyes estatales de planeación y en el contexto de operación y funcionamiento de coordinación para la Planeación del Desarrollo Regional.

La integración de cada consejo:

- Un representante por cada una de las dependencias federales y estatales.
- Los presidentes municipales.
- Los vocales de contraloría social de cada Consejo Municipal de Desarrollo.
- Un representante de cada una de las organizaciones sociales.
- Representantes de las organizaciones no gubernamentales.
- Un representante de cada una de las instituciones académicas con programas en la región.
- Los diputados locales y federales representantes de la región.

Todos estos representantes constituirán el Pleno del Consejo. La coordinación de este organismo corresponde al gobierno de cada uno de los estados y la secretaría técnica será ocupada por una dependencia federal. Además, se considera elegir un Comité Coordinador al que encabezará un presidente electo entre los organismos de la sociedad. El Consejo tendrá su Comité Técnico y las comisiones que considere pertinentes.

Consejo Directivo de Bosque Modelo

Este consejo es el encargado de dirigir y coordinar los esfuerzos del Programa Bosque Modelo, producto de un proceso de concertación y discusión durante 1996 y 1997. Ya constituido y en funciones, se inició con un grupo promotor de los sectores gubernamentales, sociales, privados y académicos, convocados por Semarnap. Este programa cuenta con un plan rector, y una visión común e integradora regional, y se han tomado los acuerdos para la constitución del Consejo Directivo (septiembre de 1997) y la elaboración de normas de operación.

Consejo directivo. Única instancia para la toma de decisiones, formado por:

- Seis representantes de comunidades y ejidos (tres por cada estado).
- Dos representantes de los pequeños propietarios (uno por cada estado).
- Dos representantes de la iniciativa privada (uno por cada estado).
- Dos representantes de las entidades federativas (uno por cada estado).
- Dos representantes de las presidencias municipales (uno por cada estado).
- Dos representantes del gobierno federal (uno para cada estado).

El coordinador general, ejecutor de las decisiones del Consejo Directivo, supervisará el avance eficiente y equilibrado de los proyectos. ***El coordinador operativo*** dará seguimiento a los proyectos aprobados para su entidad (uno por cada estado). ***Los especialistas técnicos consultivos*** proporcionarán asesoría técnica especializada; se reunirán por solicitud del Consejo Directivo, del coordinador general o de los coordinadores operativos.

Organismo ejecutor responsable: Bosque Modelo Mariposa Monarca, AC.

Asociados al proyecto:

- Socios de organismos gubernamentales.
- Socios dueños y poseedores de los recursos naturales.
- Socios de la iniciativa privada.
- Socios especialistas en apoyo técnico.
- Socios de organizaciones no gubernamentales.

Comités Sociales de Vigilancia

Con el objetivo de incorporar la población a las tareas de vigilancia y cuidado de los recursos naturales, la Profepa constituye los Comités Sociales de Vigilancia, con los cuales, además de tener un esquema de corresponsabilidad hacia la población, se fortalece la capacidad de la institución para abarcar mayores espacios y atender mejor los problemas.

De 1996 a la fecha se han conformado 24 comités de vigilancia participativa responsables de apoyar a la Profepa en esta labor, aunque no están involucrados en la inspección, la cual es responsabilidad exclusiva de la institución. Estos comités se nombran directamente en asambleas comunitarias y ejidales.

Agenda trinacional para la conservación de la mariposa monarca

La aparente fragilidad de la mariposa monarca con relación al extraordinario fenómeno migratorio que puntualmente año con año realiza, representa en la actualidad uno de los paradigmas más significativos, pues se inserta, a pesar de ella, en el complejo escenario de la globalidad y de los imperativos éticos del fin de milenio.

Las tareas que harán posible superar el estado de cosas que enfrentamos son múltiples, los factores que influyen en favor o en contra son diversos, los sujetos sociales que participan y transforman los ámbitos en donde apaciblemente la monarca completa sus ciclos vitales son heterogéneos y marcados por una enorme desigualdad de oportunidades. Ante los legítimos intereses individuales y particulares que se empeñan en garantizar su conservación, se manifiestan, con igual legitimidad, las esperanzas de miles de campesinos e indígenas por lograr una mejor calidad de vida.

La mariposa monarca se constituye, entonces, en pretexto, oportunidad y necesidad de cooperación entre los tres países de América del Norte. Permite, además, el intercambio de información científica y técnica y el diálogo entre especialistas del tema y de los asuntos que lo rodean; posibilita ubicar y reconocer que, no obstante las diferencias en los niveles de desarrollo, están dispuestos a empeñar sus capacidades de trabajo y financieras para lograr objetivos comunes, y compromete a superar diferencias de enfoque, suspicacias y prejuicios, ante la posibilidad de que la conservación del patrimonio natural se constituya en una herramienta fundamental de los modelos de desarrollo sustentable.

Si esto es así, se estará en las mejores condiciones para definir una agenda trinacional que permita, entre otros aspectos:

1. Identificar con claridad los riesgos ambientales que la mariposa enfrenta a lo largo de sus rutas migratorias.
2. Conocer las condiciones particulares en que se reproduce y desarrolla cada una de las generaciones que completan el ciclo anual.
3. Evaluar la calidad y las modalidades de manejo de los hábitats de refugio en los diferentes espacios clave para salvaguardar las condiciones óptimas del fenómeno migratorio.
4. Aclarar la situación socioeconómica de los pobladores que interactúan directamente con la monarca.
5. Dar su justa dimensión a los esfuerzos sociales, institucionales y gubernamentales, así como estimar las necesidades locales para la conservación, teniendo como base de cálculo las diferencias trinacionales en los niveles de desarrollo.
6. Promover y crear instrumentos conjuntos que nos permitan insertar la conservación de la mariposa monarca en posibles modelos de desarrollo sustentable.

Para elaborar conjuntamente esta agenda, para convertirla en programas y acciones de cooperación regional, tenemos establecidos los mecanismos de participación, consulta, consenso y solución de controversias: la Comisión para la Cooperación Ambiental, el Comité Trilateral para la Conservación de la Vida Silvestre y los Ecosistemas, el Fondo GEF y el Secretariado Internacional de Bosques Modelo.

Estamos, pues, preparados para enfrentar el reto, estamos a tiempo, todavía, de que la tarea conjunta de cooperación regional se traduzca en la certidumbre de que las generaciones presentes y futuras disfruten de una de las maravillas naturales más singulares del planeta; de que los indígenas y campesinos tengan la oportunidad de mejorar su calidad de vida, conservar sus recursos naturales y construir sus propios modelos de desarrollo regional sustentable.

Ecosystem sustainability

by ***Dr. David A. Gauthier***
Executive Director
Canadian Plains Research Center
University of Regina
Regina, Saskatchewan, Canada

Introduction

I want to thank the organizers of this conference for allowing me the opportunity to talk to you on a topic that you all feel so deeply about. I have listened to you with deep respect for the commitment and passion you have collectively brought to these discussions.

I suspect that over the past few days, some of you have heard more than you ever wanted to know about monarch butterflies. My presentation focuses less on butterflies and more on the ecological context within which they exist. It builds upon the excellent information provided in earlier presentations by Lincoln Brower and Carlos Toledo Manzur. Dr. Brower suggested that while it is necessary to maintain and build upon the detailed biological research that is being conducted, it is also important to add an ecosystem perspective. That theme was built upon in panel discussions and in Carlos Toledo's talk about a sustainable development strategy for monarchs that stressed the importance of incorporating social and economic needs within the strategy. He shifted the focus from the biology and ecology of the monarchs to the level of a regional vision for sustainable development.

This presentation shifts that focus even further from site and regional levels to thinking about ecosystems and sustainable development at a continental scale. You may be thinking that such a coarse scale perspective has very little to do with the monarch core reserves. What, for example, does the price of wheat in my province, Saskatchewan, in Canada, have to do with monarch conservation issues in Michoacán State? Perhaps that question can be answered before the end of this presentation. There is an urgent need for us to collectively reconcile the differences in our values. An integrated, ecosystem perspective helps us to reconcile those values.

Ecosystem perspective and sustainable development

In thinking of ecosystems, our collective challenge is one of trying to fit human needs and wants within ecological systems that are poorly understood and are essential for human survival. Human needs exist within several different spheres of existence (Figure 1) —we are individually different; as individuals, we live within populations that are nested within cultures; those cultures differ within societies that are structured within different levels that encompass all humans; and that we all exist within a large ecological sphere. Human needs for survival, security, belonging; our needs to be loved, respected and fulfilled—all stretch across these systems and express themselves in different and dynamic ways.

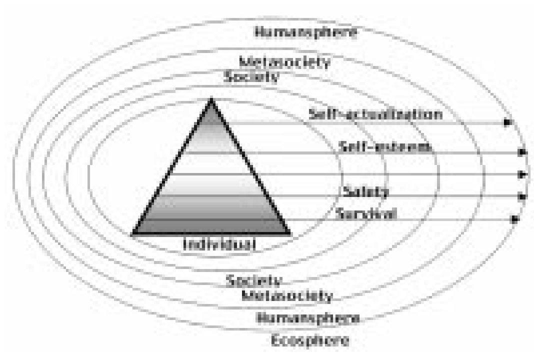

Figure 1. Spheres of existence

We develop models of the ways we should lead our lives in order to meet our needs and wants across these various systems. Sustainable development is one such model. It is a type of a contract we make among ourselves that commits us to meeting our own needs without seriously compromising the rights of others in both future and present generations to meet their needs.

The concept of sustainability is not new. It is a common theme in the oral histories of tribal peoples in all parts of the world. In those histories it is often presented as a parable or a fable about the importance of living within and as part of nature, of saving for the future and ensuring that the environmental attributes that support life are maintained.

Today we have three principal environmental goals for sustainable development: to assure ecosystem integrity; assure human health and well-being, and assure natural resource sustainability. Sustainable development cannot be achieved without achieving those three goals.

Typically, five questions are asked in regard to sustainability: What is happening? Why is it happening? Why is it significant? What is being done about it? Is it sustainable? These are sometimes difficult questions to answer for many reasons. Traditionally, humans tend to concentrate inwards, focusing first on our own individual problems and needs, and then those among our friends, our regions and within our own countries. Often, we look outwards only in relation to our own problems. This is a reality of the human condition. Another reality is that we have established government systems that are separated in their mandates and that, traditionally, have not rewarded attempts to cross disciplinary or agency boundaries.

This separation is reflected in traditional economic models. Sustainable development requires that economic models must be integrated with cultural and ecological models. Traditionally, this has not been the case.

This separation of knowledge and mandates has left us poorly prepared to deal with interdisciplinary questions. Liberal arts programs used to be dominant offerings within universities. In such programs, scholars have a comprehensive sampling of the arts, sciences and humanities. Increasingly, universities are producing specialists. We have a challenge in our educational system to continue to produce specialists at the same time that we produce those who are capable of integrating results. Physical scientists need to talk to social scientists who need to talk to engineers who need to talk to philosophers. But there is no reward system for those who do such things. Those of you who are simply not interested in the latest biological fact to be discovered about monarch butterflies are asking what that fact and all of the other facts have to with your life. And there seem to be few scientists and managers who can answer that fundamentally interdisciplinary question for you.

Sustainable development at the level of ecosystems requires a shift in our focus to a more integrated approach. It suggests that we think, plan and act in terms of ecosystems. An ecosystem is a dynamic complex of organisms, including humans, and their physical environment, interacting as a unit. Ecosystems vary in size and composition; they can be as large as the entire ecosphere or they can be very small areas; they can be pristine or heavily human-modified systems. In its broadest sense, an ecosystem includes environmental, social, and economic elements. The discussions at this conference over the past few days about the need to integrate information about the biology of monarchs with human social and economic concerns in the hope of maintaining healthy systems has essentially been a discussion about ecosystem sustainability.

This focus is timely in its recognition that our traditional separation of knowledge ultimately fails us if we cannot find the ways to integrate detailed knowledge. We do not live in a partitioned world, although we often behave as though we do. An ecosystem perspective requires that we accept that environment and human activities are inseparable; not just accept it theoretically or intellectually, but in terms of actions. It requires that we accept that humans are a major driving force of ecological change and that there are certain limits or thresholds which, if exceeded, will result in damage. Intellectually we accept the need for long-term perspectives in our management of lands and waters, but too often we put aside or ignore these long-term perspectives, or develop them only in certain sectors or for certain species, or fail to develop the linkages among the sectors.

In managing for healthy ecosystems, we cannot sustain the health of one component to the detriment of another. The health of social, cultural, economic and environmental systems needs to be sustained. For that goal to be accomplished, cooperative partnerships are needed. Many of you are here because you see the advantages of partnerships as a way to help resolve your individual or community dilemmas. Is it possible to have different personal, societal, and economic goals and still be able to agree on broader ecosystem goals within which individual goals can be adapted? One lesson that I have learned from my travels to various countries is that if a way cannot be found to respect and accommodate the basic needs of others, sustainability will never be achieved. That is why it is a fundamental principle that sustainable development can only proceed on the basis of satisfaction of basic human needs and wants.

Mapping ecological regions

Proceeding on that basis, let us view this issue of ecosystem sustainability from another perspective. Figure 2 shows the movement of particular pollutants into Canada. Canada has a problem related to the deposition of acidic air pollutants. While we Canadians generate our own pollutants, they are also transported from other countries by wind and ocean currents. Canada cannot escape the physical laws that generate wind or ocean currents that lead to pollutants being deposited in our country. What we can do is enter into partnerships within our own country and with other people from other places to help us. It is the only way to effectively address the problem.

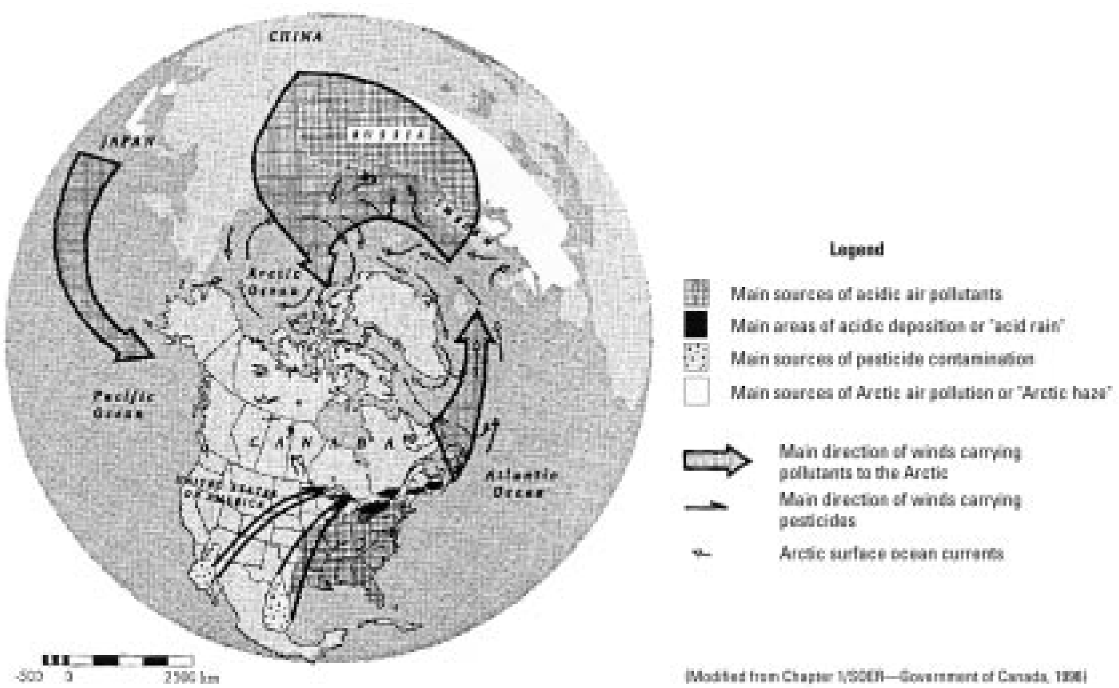

Figure 2. Acid rain pesticides and arctic haze

We have entered into just such a partnership called the North American Free Trade Agreement (NAFTA). Within the context of that agreement, forward thinking people saw that more sensitive environmental decision-making was required. Unlike previous efforts on particular themes, this partnership required at least a continent-wide ecological perspective that could help to provide a common bond among the three countries: a common way of looking at issues.

Thinking, planning and acting in terms of ecosystems among countries requires a picture of ecosystems to which all can agree. It should display ecosystems at different scales so that issues can be examined at both continental and within-country scales. Previous partnerships layed the ground work for the NAFTA Commission for Environmental Cooperation to bring together experts from the three NAFTA countries to work in a cooperative and consensual manner to create such an ecological picture.

Many scientists helped to apply these and other concepts to our North American ecological region mapping. Dr. Francisco Takaki, Dr. Gerardo Bocco, who is with us at this conference, Dr. Miguel Equihua-Zamora, Araceli Vargas-Mena and Arturo Victoria, for example, in Mexico were important and essential contributors. Ed Wiken of Environment Canada led the contributions from Canada, as did Jim Omernik of the Environmental Protection Agency from the United States. These Mexican, US and Canadian scientists used thinking about ecological regions and ecological classification to develop standardized ecological maps at multiple scales to be used for decision-making. Victor Lichtinger and the Commission for Environmental Cooperation were critical to the success of this project. I also want you to know that without the dedication and perseverance of Irene Pisanty of the Commission, this work would not have been completed. I want to extend my personal and professional thanks to her for her dedication and her courage in seeing this process through to its conclusion.

The scientists used various diagnostic criteria to construct the boundaries of the ecological regions. They used a mosaic of components that could vary from one ecological unit to another. There was much flexibility in the design criteria. Scientific data used to construct the regions were interpreted and re-interpreted using a broad range of ecological characteristics. The scientists also considered human influences on the landscape. They used principles of aggregation and abstraction to help define areas. They recognized that there was a subjective element involved in defining boundaries, i.e. there was an “art” as well as a “science” to defining ecological boundaries.

The scientists followed key features of ecological classification, including: the consideration of humans as part of the ecological systems; holistic concepts; the variability in the importance of variables from one place to another; and the hierarchical, nested nature of systems. They recognized that boundary lines are generally zones of transition and that the lines drawn on a map imply a greater degree of accuracy and knowledge at any scale than normally exists. The details of the methodology are outlined in the CEC’s report *Ecological Regions of North America* that is available in Spanish, French and English.

Three hierarchical levels of mapping of ecological regions were achieved. Each is at a different scale and each serves different purposes. The names chosen for the regions try to respect each country’s wishes while also trying to achieve consistency, particularly for regions that crossed international boundaries. Figure 3 shows the Level 1 ecological regions for North America with the country boundaries overlaid. There are 15 at this level for the continent, and they vary in their sizes and distribution. The much greater biodiversity of Mexico is reflected in the greater delineation of regions at this level for Mexico. Physical, biological and human characteristics of each region are summarized in the report.

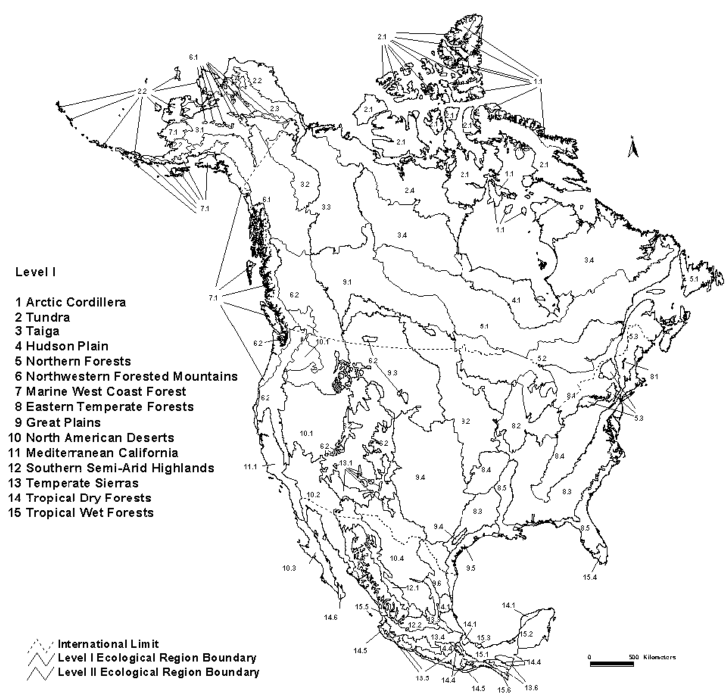

Figure 3. Ecological Regions of North America: Level I and Level II

At a more detailed spatial scale is Level 2, in which there are 52 ecological regions. Again, physical, biological and human characteristics of each of these Level 2 regions are summarized in the report. Some of you have already seen the paper map with the table of characteristics on the back of the map. In addition, a third, more detailed level of mapping is in preparation for release in 1998.

This hierarchical, nested system of mapping ecological regions provides a tool, analogous to a microscope. We can zoom in to more detailed levels, which we need to do to understand some issues. But we can also zoom out to see a larger picture which is necessary for other issues. In Canada, we could not have dealt with the acid rain issue without the ability to zoom both in and out.

Many jurisdictions within North America, including Mexico, such as you saw from Carlos Toledo's presentation, have developed quite detailed ecosystem maps and databases that allow for more detailed site-specific studies. These coarser levels allow each jurisdiction to place its own interests within the ecological contexts of other jurisdictions.

I asked you at the start of this presentation what the price of wheat in Saskatchewan Canada had to do with monarch conservation issues in Michoacán. I think you may already know the answer. The amount of land put into wheat production in my province is related to the price the farmer can get for the wheat. If the prices are high, they will grow more wheat. They will cultivate more land to grow that wheat. They will use pesticides and herbicides to destroy insects and plants that interfere with their production of wheat. In the process, they will destroy monarch range. They will not do it because they want to hurt the people of the communities of Michoacán State in Mexico. They will do it because, like you, they are trying to survive and support their families. Similarly, the industrialists in the northeastern United States do not intentionally set out to destroy the productivity of Canadian lakes with acidic pollution.

If I were to ask many of the farmers in Saskatchewan about the problems of the *ejidos* in Michoacán, the majority would not likely know to what I was referring. If, however, the problems were explained to them, I believe that they would care and that they would want to find a way to reduce the impact of their activities on you. And I would like to think that if you knew about their problems and concerns, you would not want to do things that would hurt them.

Protected areas

We have mapped continental ecosystems to try to serve broad policy objectives; to help us in that shift in focus from jurisdictional concerns to broader ecological concerns. However, policy objectives can be confusing. I want to use the example of protected areas to explore this issue further. Certainly there seems to be a great deal of discussion about protected areas in the context of monarch butterflies, so perhaps some of these thoughts will be of value.

In the context of protected areas, there are many conflicting pressures. Managers can become confused about which interests they should be serving. Should society be sustaining the ecological integrity of systems, or optimizing tourism opportunities, or facilitating regional economic development, or saving a butterfly species? Are all of those objectives in conflict?

Perhaps a story will be helpful to reflect on this matter. One day two men visited a rabbi, a Jewish teacher, to get his ruling on a problem that they were having. It seems that the two men were neighbours. One man had a goat and this goat would go into the neighbour's yard and eat vegetables from the garden. The man complained to the rabbi that his neighbour's goat was destroying his vegetable garden and costing him money. The rabbi said "You are right. This is indeed a problem." He asked the owner of the goat what he had to say in his defense. The man said that he had offered to share with his neighbour the cost of building a fence between their two properties so that the goat could not go into his neighbour's vegetable garden. But his neighbour refused to share in the cost. The goat owner was poor and therefore could not afford to build the fence himself. The rabbi replied that, "Yes, when you explain it that way, I can certainly understand your problem." He thought on the matter for some time and then told the men that he could not help but conclude that they both had a problem and that they were both right. The men got very angry that the rabbi could not solve their problem for them and went away. That evening, when the rabbi returned home, he told his wife the story of the two men and the goat. The rabbi's wife got angry with him, calling him an old fool, and saying "Obviously they can't both be right." He looked at her thoughtfully and said "You know, you're right too."

People tend to dislike this story for one of two reasons: either they see no humour in it or, secondly, and perhaps more importantly, many people like to think in terms of right and wrong. Sometimes, however, and perhaps many times, there is only right and right. I have not heard right and wrong in listening to you over the past few days. I have heard people with different perspectives, each of them right in his own way, who need to find a way to appreciate each other's views.

In discussing protection, therefore, who are we protecting things for and what are we protecting things from? Is it possible that there is a right amount for everyone and that we could manage changes to this amount as conditions change and as people's values change? Often when people talk about protection, the question is asked: "How much is enough?" What criteria should be used to determine if "enough" has been protected? Is 12% of an area enough? Is 12% of a core reserve enough? Is 12% of the ecoregion in which the core reserve exists enough? Is 12% of Michoacán State enough? Is 12% of Mexico enough?

Would it help in considering these questions if it was possible to know how well biodiversity might be protected throughout an entire ecological region? And if that information could be related to land use patterns and population information, and other factors important in sustaining and improving the lifestyle of people, as Carlos Toledo Manzur suggested, would that help in making decisions about protection?

Do natural and cultural values always have to be in constant tension with one another? Is it possible to have "working landscapes" within protected areas or is that simply an illusion? People in Mexico are perhaps more comfortable with the concept of working landscapes than many people are in Canada and the United States. There is much to learn from Mexico in that regard. Being able to look across countries within ecological regions at different management strategies allows us to share through the common language of ecology.

Table 1 lists many of the reasons that have been advanced for protection of biophysical diversity. All are legitimate and all meet human needs and wants. Mexico's monarch reserves do not have to be all things to all people. Would it not be sufficient if they accomplished just some of these objectives? Whatever the objectives, the monarch reserves should at least share these characteristics: a legal status; a management authority; restrictions on inappropriate activities; regulated land use; and resource management and public education programs.

Table 1	Reasons for protecting areas
• for future generations	
• wilderness preservation	
• for human enjoyment	
• protect specific cultural features (e.g., historic sites, landmarks; areas of palentological and archeological significance)	
• for their intrinsic characteristics (not their potential for human uses)	
• protect specific natural or unique landscape features	
• for the conservation of life-support systems	
• protect areas of scenic value	
• for the conservation of biological diversity (totality of genes, species and ecosystems)	
• tourism and recreation	
• maintenance of cultural and traditional attributes	
• for education and interpretation	
• for their spiritual and/or ethnic significance	
• maintenance of environmental services	
• scientific research and monitoring	
• sustainable use of resources from natural ecosystems	

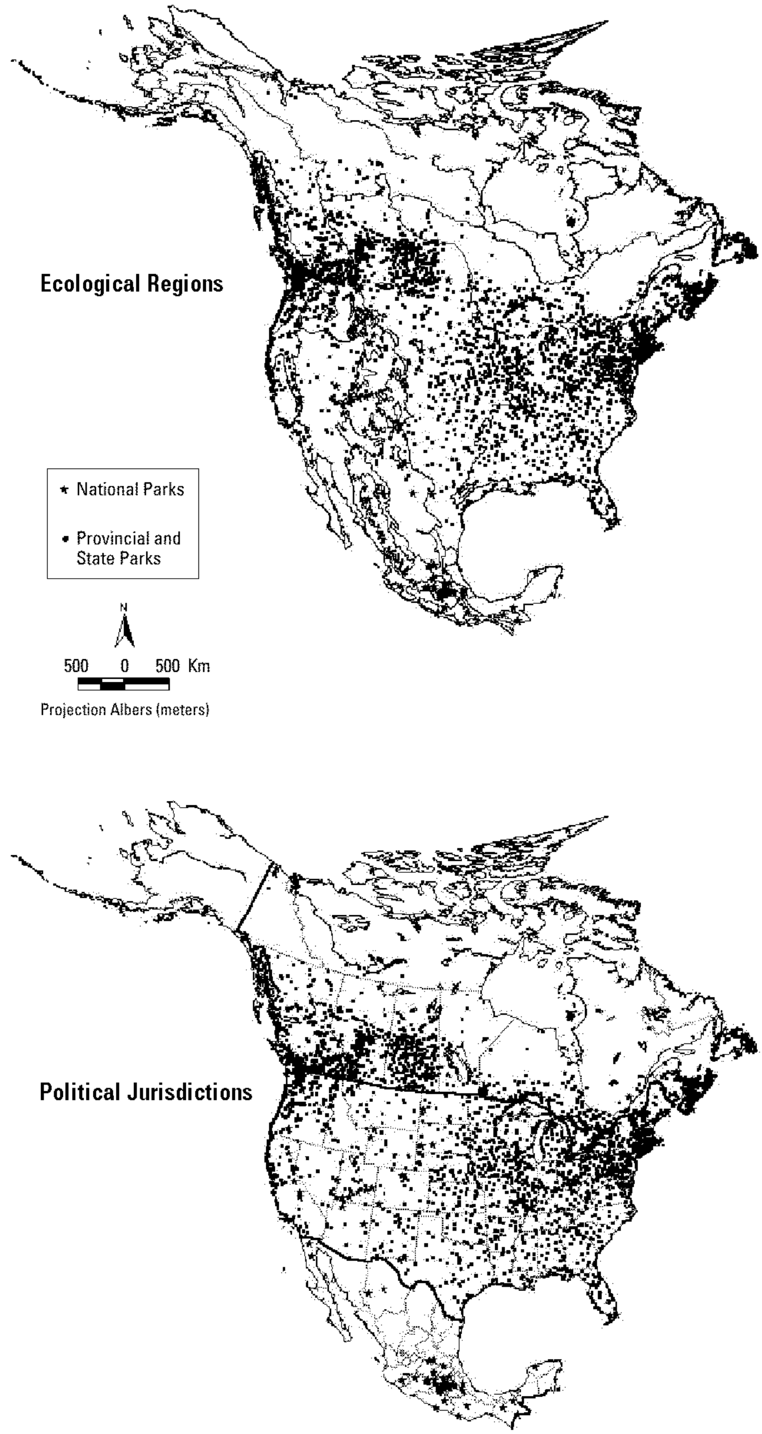

Figure 4 shows a continent-wide perspective of the distribution of national parks and state and provincial parks in North America according to ecological regions and jurisdiction boundaries. The database is incomplete even for only those types of parks. Nonetheless, these maps allow comparisons to be made among different jurisdictions and ecological regions. To date, most of the areas of North America are associated with landscapes; fewer are linked to seascapes. It is interesting that the pattern of dots often mimics a human population map. The Pacific and Atlantic coastal areas as well as the Great Lakes area show marked concentrations. In North America about 2/3 of these types of parks are located in 3 ecological regions—the Eastern Temperate Forests, the Great Plains and the Northern Forests. In part, the distribution pattern is a mirror image of cultural patterns.

In Canada, for example, political, cultural and economic factors strongly influenced development along the 49th parallel. In Mexico, Mexico City has exerted a central pull on culture and economics for thousands of years. The dot pattern does not, of course, fully explain the status of parks since they do not represent the size of parks or their condition. For example, in northern Canada there are fewer dots, but the parks in the northern parts of the continent are larger.

Figure 4. National parks, provincial/state parks according to Level I ecological regions of North America and political jurisdictions

Jurisdiction boundaries do not have to be ignored. They could be overlaid onto the ecological region map as well as many other types of information. The ability to integrate different types of data helps in meeting management needs. Monarch migration routes, overwintering sites and breeding grounds can be considered relative to the ecological characteristics of areas. Such a map could be overlaid with existing protected areas and to allow discussion of protection throughout the full range of the monarchs. Monarchs could then be considered relative to the biological richness of each of the regions, a useful approach in helping to determine priority areas for research and management.

Great plains

I want to shift focus again to one particular ecological region—the Great Plains of North America, and one part of it, the prairies, in my province Saskatchewan, in Canada. The Great Plains of North America occupy 3.5 million square kilometers, covering the widest latitudinal range of any single North American ecological region. This region is a culturally molded system in that it has been heavily influenced by humans. In Canada, this is the most heavily disturbed ecological region.

I want you to imagine that the year is 1840. I want you to imagine that you are on a hill in the prairie grasslands of North America, perhaps even in the prairies of southern Saskatchewan. Before you, as far as the eye can see, is an unbroken expanse of native grasses. There are no roads, no telephone lines, no cities, no airplanes in the sky. There are no noises from traffic or industry. Those things do not exist yet in this place. But below you, surrounding the hill that you sit on, there are millions of buffalo. They are moving in a massive swarm across the grasslands. The noise of their hooves pounding on the prairie soil is deafening; clouds of dust are thrown up as they pass beneath you. They seem like one continuous mass of life, rolling over the landscape as far as you can see. And if you could see beyond the horizon, there would be millions and millions more buffalo, mixing with millions of antelope and elk.

The name of my city is Regina. It means "Queen" and it honours the Queen of England. Before it was called Regina, however, its name was "Pile-of-Bones" (*montón de huesos*). It was called "Pile-of-Bones" because, by 1870, in a period of only 30 years, the buffalo had been virtually exterminated. All that was left were masses of bones spread over the prairies. The "bone-pickers," the people who collected the bones, would bring the bones to places like "Pile-of-Bones" and the bones would be sold and used for various things. The native Indians relied on buffalo for their way of life, and when the buffalo were killed, the Indian way of life changed forever. It is not likely that there will be ever again in the history of this planet vast herds of buffalo roaming the North American plains. There will never again be the plains wolves or the plains grizzly bears that fed on the buffalo. There will never again be a traditional native Indian way of life on the plains of Canada. Will a visitor to Michoacán State 30 years from now hear stories about the millions of butterflies that once existed but will never be seen again?

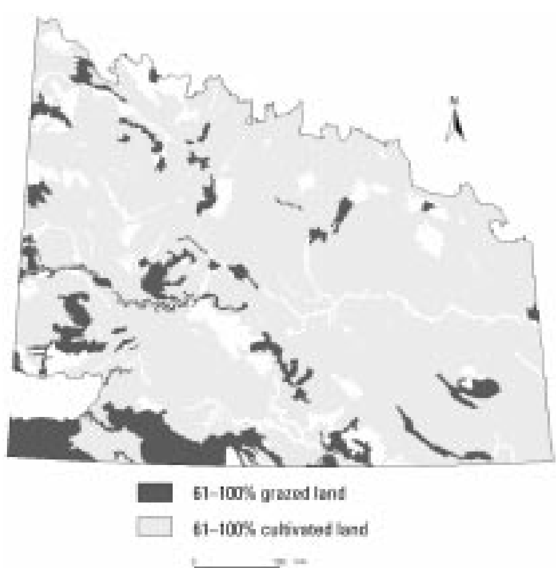

Figure 5. Cultivated and grazed land—prairies of Saskatchewan, Canada

Figure 5 shows that much of the prairie ecological region of Saskatchewan is highly cultivated and grazed. Most of it is quite altered from its original native vegetation. Wheat and cattle are important products. In Saskatchewan, more than 80% of the economic activity of the entire province is generated in this ecological region.

We often think of the prairies as wide-open spaces of rangelands and croplands. However, the prairies also have the highest density of roads of any place within Canada despite their low population density. There have been significant declines in Saskatchewan's rural population. These population declines have important implications for sustainable development in this region. The view that the prairies are dominated by rural populations is a myth. For the entire Canadian prairies, farmers make up less than 10% of the population. These demographics have caused great concern about the sustainability of agricultural production. Rural populations are also declining in Mexico (Figure 6). Is it possible that your young people in your rural areas in Mexico are leaving to find opportunities elsewhere? What will happen to your lifestyles and communities as your populations decline?

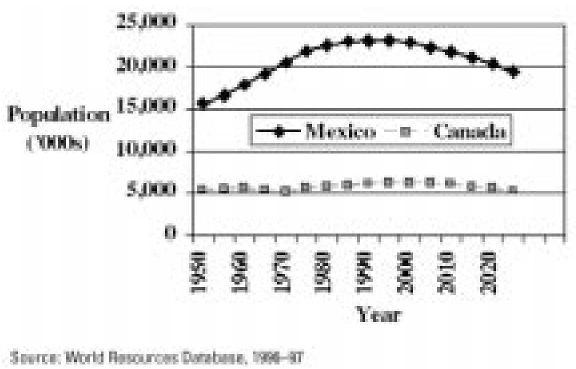

Figure 6. Rural population trends—Mexico and Canada

One thing that is happening in the prairies of Canada is that as our declining number of farmers are asked to produce greater amounts of food from the land, they have to use greater quantities of pesticides, herbicides and fertilizers. There have been substantial increases over 20 years in the use of chemical herbicides and fertilizers. People are very concerned about the health effects on humans as well as other species and there are many programs to monitor the environmental and human health effects of agricultural activities.

Nonetheless, the changes made on the prairies to facilitate economic development have led to important changes in wildlife habitat and species diversity. Ecological sustainability on the prairies of Saskatchewan now requires that restoration must become an important part of our thinking, although the costs of ecological restoration are high.

Figure 7, taken from satellite photos, shows remaining rangeland and pasture for the prairies of Canada. The vast majority of the landscape is altered and much of what does remain is fragmented, small and isolated. The lesson to be learned is that when there is little left, options for management become very limited.

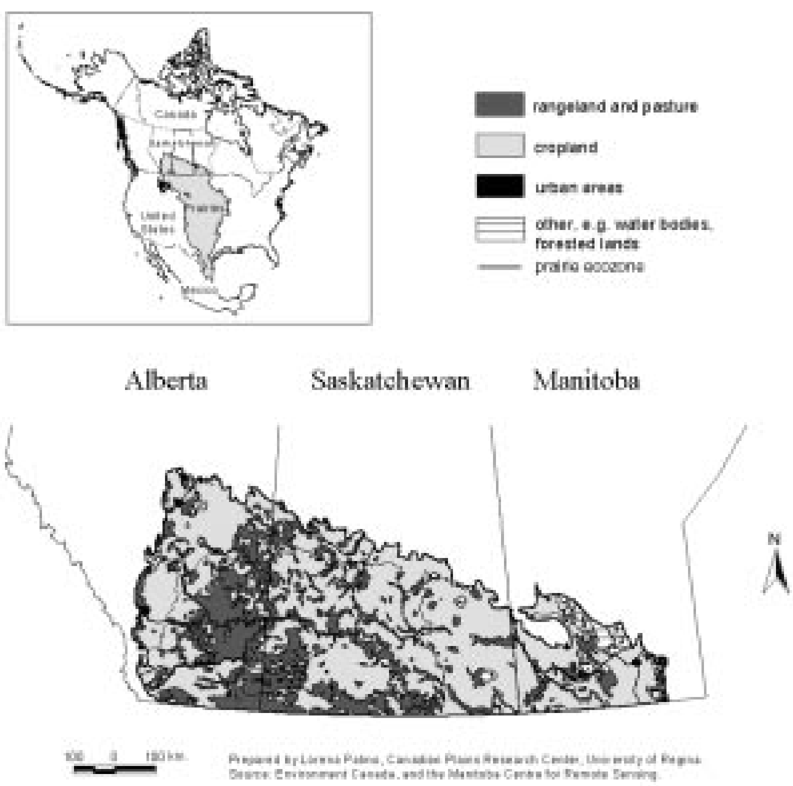

Figure 7. Cropland and rangeland for the prairie ecozone of Canada

Compound that problem with the following scenario. Figure 8 shows the boreal and prairie regions of Canada. Global climate change models suggest changes in these regions of the magnitude shown in the bottom map. Fertile croplands of parts of southern Saskatchewan will become arid areas. Species will shift north. Will these shifts be beneficial for monarch butterflies, for farmers, for people in cities? What will happen to the distribution and productivity of cropland and rangeland?

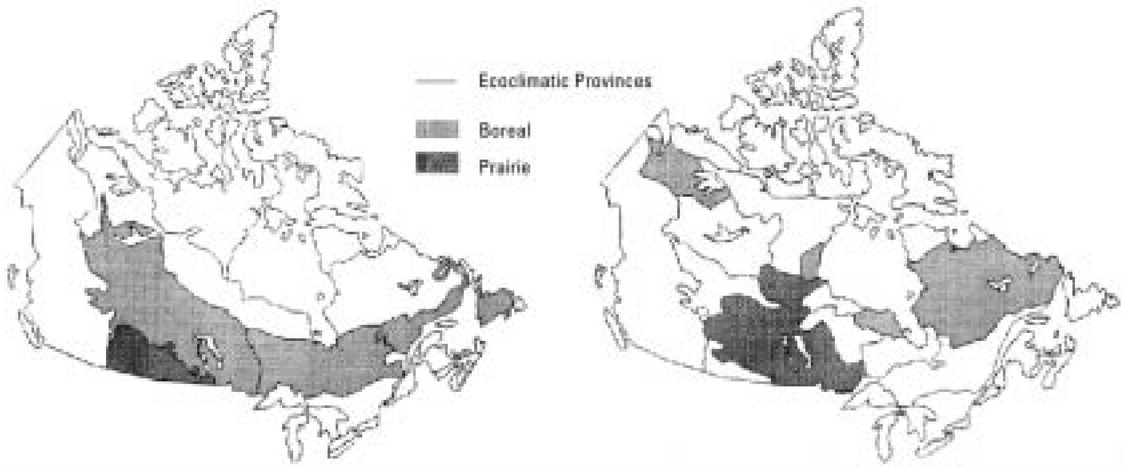

Figure 8. Boreal and prairie ecoclimatic regions

This is all very complicated and the answers are not clear. These problems require the attention of committed and intelligent people. The word “intelligence” comes from two words—“inter” and “legere.” “Inter” means “between” and “legere” means “to choose.” An intelligent person, therefore, is one who has learned “to choose between.” An intelligent person knows that good is better than evil; that confidence is better than fear; that love is better than hate; that gentleness is better than cruelty; that compassion is better than arrogance; and that truth has more virtue than ignorance.

Intelligent people have the capability and the tools to examine the linkages among our countries. In Mexico you are, of course, most interested in your immediate problems and futures, as you should be. Your focus is on your own home place, as it needs to be. But is it possible that intelligent persons could take all of these factors that we know to be important in one program—for example, in Michoacán state in the country of Mexico—and could those people assess sustainability in an ecological context in that area? And could this be more than a biological study—could it be one that works with local people and addresses long-term requirements for meeting basic needs, and assesses impacts of human activities, and helps to develop sustainable economies and sustainable conservation practices? Is this not where the model forest program can be of help and is this not what Carlos Toledo was suggesting, at least in part, in his presentation?

Work with your government to address the issues of meeting your basic needs and wants. Work for firm, long-term commitments. Make this part of the program that Carlos Toledo described. In that program you will use indicators that, when tracked over time, give you information on trends in the condition of the state of the environment, natural resource sustainability and related human activities. Many were listed in the action items that have already been presented at this conference. They focus on trends in environmental changes, stresses causing them, how the ecosystem and its components are responding to these changes, and societal responses to prevent, reduce or mitigate those stresses.

This program, through consultation with the communities, will identify the issues. Many are obvious already. The issues should be ones of long-standing importance to you. For each issue, potential indicators of stress, condition and societal response are identified. Stresses influence condition and effects, which you well know, and they can be linked to societal responses which in turn influence the human activities and stresses. Natural forces obviously cause stresses, but the focus for indicators is on human causes since decision-makers in society have more ability to do something about them.

Keep in mind that good indicators are sensitive to change, supported by reliable, readily available data, and understood and accepted by intended users.

Before I leave you I want to relate one last story.

Samuel Clemens, better known as Mark Twain, who wrote *Tom Sawyer* and *Huckleberry Finn*, had a deep distrust of the new technologies that were appearing in society as he got into his older years. He was particularly unfond of the new telephone that his wife had convinced him would make it easier for him to talk with his friends. But he could never figure out how to properly use the telephone. He would pick it up and start talking into it expecting whomever he wanted to talk to would be immediately on the other end of the line. When that didn't happen, he would start to curse and, by all accounts, he could curse very colourfully and at length. His wife, a very religious person, was deeply upset by her husband's use of foul language. One day after one particularly violent outburst by her husband on the telephone, she decided she would teach him a lesson. The next day, when he was sitting in the parlour by the phone, she walked over to it, picked up the phone and then very methodically and carefully recited all of the curses she had heard him using. She then put down the phone and triumphantly turned to him to see if he had learned his lesson. He looked at her with fond bemusement and said "My dear, you have all of the words, but none of the music."

In closing, I must tell you that over the past few days, I have heard many words. I think that you may be very close to hearing the music.

Congratulations on all of your efforts and thank you for allowing me some time to talk with you. I hope that this talk has allowed you at least a brief rest. I also hope to be able to return to Michoacán State and to see many of you successfully working the land, many of you conducting successful research—and I hope to see butterflies.

Suggested reading

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Capítulo/Chapter 1

Biología de la mariposa monarca
Biology of the Monarch Butterfly

Jürgen Hoth
"La situación en la que se encuentra actualmente el bosque es el resultado de diversos y constantes cambios. Y más vale que entendamos esos cambios si queremos proteger a la mariposa monarca."

Karen Oberhauser
"Someone said yesterday during this meeting that he resented hearing that the monarch sites were 'discovered' only twenty-one years ago. Now, we all know that isn't true. We realize that you have known about and celebrated the presence of the monarch for centuries... maybe scientists are just a little bit slow. It took us several decades of looking very, very hard to find them here."

Phil Schappert
"A good conservation plan needs to start from good basic research about the biology of the organisms that you're trying to conserve."

Introducción

por ***Karen Oberhauser***
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Más de un millón de especies de insectos hay en el mundo, pero tal vez ninguna que no sea plaga despierta tanto interés como la *Danaus plexippus*: la mariposa monarca. Esta atracción la comparten niños y adultos, conservacionistas y educadores, naturalistas y jardineros. También se interesan en ella los biólogos, científicos que la han elegido como vehículo para comprender conductas diversas, como el apareamiento; la interacción de las aves de presa y sus víctimas y de plantas y herbívoros; las respuestas fisiológicas al cambio ambiental, y la actividad migratoria de los animales. En esta sección, los biólogos especializados en las mariposas monarca describen su trabajo relacionado con estos y otros aspectos.

¿Por qué toda esta atención? Es sencillo comprender lo que motiva el estudio de insectos que constituyen una plaga. Un primo distante de las monarca, el *borer* europeo del maíz (*Ostrinia nubilalis*), cuesta millones de dólares anuales a los agricultores de Estados Unidos. Otros parientes aún más distantes, los mosquitos del género anofeles, trasmiten un parásito que causa el paludismo, matan a más de dos millones de personas al año e infectan a otros 300 millones. Por otro lado, algunos insectos benefician a los humanos; es fácil comprender el interés de los científicos en las abejas (*Apis mellifera*), que han provisto de miel a los humanos durante más de diez mil años, y en una multitud de insectos parásitos utilizados como agentes de control biológico de las plagas de cultivos. Estos insectos, y miles más, tienen grandes efectos medibles en los seres humanos. No es éste el caso de las monarca: si se extinguieran mañana, es muy probable que el impacto en el bienestar material humano no fuera susceptible de medición.

Muchos de los científicos que han elegido a las monarca como objeto de estudio tienen razones convincentes. Por su muy larga migración, las monarca son únicas entre los insectos, y este enigma ha llamado la atención de los biólogos durante casi un siglo. En este volumen, Calvert y Wagner, Rogg *et al*., y Pérez desarman los mecanismos y los patrones de esta increíble proeza. Es posible que esta migración afecte la interacción de las monarca con otros organismos; Altizer y Oberhauser exploran la relación entre la preponderancia de un parásito de la monarca y la distancia de migración. Los sitios de invernación a los que emigran las monarca están amenazados por las actividades humanas, de allí que su conservación anime el trabajo de Alonso.

Sin embargo, casi todos los insectos se aparean; muchos experimentan diapausas estacionales, y la distribución y la abundancia de cada insecto se ven afectadas por el clima. Así, Frey, Oberhauser, Van Hook, Wijesuriya, Goehring, Malcolm *et al*., y Zalucki y Rochester podrían haber elegido otra del aproximadamente un millón de especies de insectos que existen en el mundo. Sus razones para acercarse a las monarca, como las de otros biólogos a ellas dedicados y no incluidos en este volumen, son tan variadas como las de los niños, educadores y naturalistas que las aman. Algunos habrán tenido en la infancia una experiencia que los condujo a esa elección, o tal vez se trate de una decisión pragmática ante un ser vivo más o menos abundante y fácil de criar. Pero me atrevería a afirmar que gran parte de estas decisiones pragmáticas se han tornado en fuertes vínculos debidos a lo maravilloso y asombroso de las monarca, de modo que nos resultaría muy difícil cambiar de organismo de estudio.

El conocimiento del mundo natural es importante. A medida que los humanos requerimos más y más recursos de la tierra para alimento, vestido y refugio, tenemos que comprender la biología básica de los organismos con los que compartimos el planeta. ¿Y qué mejor organismo que la “monarca” de las mariposas? Disfrute el lector del siguiente capítulo, y celebre con nosotros esa por demás inusitada biología.

Introduction

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There are over a million insect species in the world, but it is likely that no other non-pest species attracts as much attention as *Danaus plexippus*, the monarch butterfly. This attention comes from children and adults, conservationists and educators, naturalists and gardeners. It also comes from biologists, scientists who have chosen monarchs to help them understand topics as diverse as mating behavior, predator-prey interactions, plant-herbivore interactions, physiological responses to environmental change, and animal migration. In this section, monarch biologists describe their work on these and other topics.

Why all this attention? The motivation behind the study of insect pests is easy to understand. A distant cousin of monarchs, the European corn borer (*Ostrinia nubilalis*), costs farmers millions of dollars per year in the US. Even more distant relatives, mosquitoes in the genus *Anopheles*, spread a parasite that causes malaria, which kills up to 2 million people every year, and infects about 300 million others. On the other hand, some insects benefit humans—it is easy to understand scientists' interest in honeybees (*Apis mellifera*), insects that have provided honey harvests to humans for over 10,000 years, and in a myriad of parasitic insects used as biological control agents of crop pests. These insects, and thousands of others, have large, measurable impacts on humans. Monarchs, on the other hand, do not. If monarchs became extinct tomorrow, there is a good chance that the impact on material human well-being would not be measurable.

Many of the scientists who have chosen monarchs to study have reasons that could be explained coherently. Monarchs are unique among insects in their long-distance migration, and puzzles generated by this fact have attracted the attention of biologists for almost a century. In this volume, Calvert and Wagner, Rogg et al., and Perez continue to tease apart the mechanisms and patterns of this incredible feat. This migration is likely to affect interactions between monarchs and other organisms, and Altizer and Oberhauser explore the relationship between the prevalence of a monarch parasite and migration distance. The overwintering sites to which monarchs migrate are threatened by human activities, and conservation of the migratory and overwintering phenomena has motivated work by the Alonsos.

However, almost all insects mate, many undergo seasonal diapause, and the distribution and abundance of every insect is affected by climate. Thus Frey, Oberhauser, Van Hook, Wijesuriya, Goehring, Malcolm et al., and Zalucki and Rochester could have chosen another of the million or so insect species in the world. Their reasons for choosing monarchs, and the reasons of other monarch biologists whose work is not represented here, are as varied as those of the children, educators and naturalists who love monarchs. They may have had childhood experiences that drove this choice, or they may have made a pragmatic choice of an organism that is relatively abundant and easy to rear. But I would guess that, for most, pragmatic choices have evolved into strong connections driven by amazement and wonder, and that we would have a difficult time switching study organisms.

Knowledge of the natural world is important. As humans require more and more of the earth's resources for food, clothing and shelter, we need to understand the basic biology of organisms with which we share the planet. What better organism to study than the "monarch" of butterflies? Read the following chapter, and celebrate with us their incredible biology!

Coercive mating by overwintering male monarch butterflies

by ***Karen Oberhauser*** and ***Dennis Frey***

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Abstract

We studied two aspects of mating behavior in overwintering monarch butterflies: their coercive courtship behavior, and the occurrence and timing of mating during the overwintering period.

Approximately one third of male-female mating attempts resulted in coupling, and the duration of attempts ranged from one second to over 30 minutes. About one quarter of all attempts involved two males, and male-male attempts were as long as male-female attempts. Mating attempts involving previously-mated females were longer than those involving virgin females. Mating males were in poorer condition than roosting males, and mating females in Mexico were larger than roosting females. We use a cost/benefit model to interpret these results. We argue that the payoff of winter mating is probably low for both sexes. There is a good chance that females will remate, and last-male sperm precedence in monarchs means that sperm transferred during winter matings are likely to be superseded by subsequent matings. From the female perspective, the costs of mating (carrying the additional mass of a spermatophore and possible physical damage) may not be offset by benefits of winter matings. We suggest that females that could suffer the cost of a ruptured bursa copulatrix from mating too often or too soon after a previous mating are likely to struggle longer in a subsequent mating, and that males in poor condition are more willing to mate and thus incur reduced future fitness since they have a smaller chance of surviving to mate later. Males in Mexico may be selecting large females, although the prevalence of male-male attempts argues that males are not very discriminatory. We propose that male coercion in monarchs evolved in the context of overwintering. At overwintering sites, males with low prospects for future reproductive success co-occur with females that have little to gain by mating, but less to lose from unwanted matings than summer females who face the pressure of needing to maximize time for oviposition.

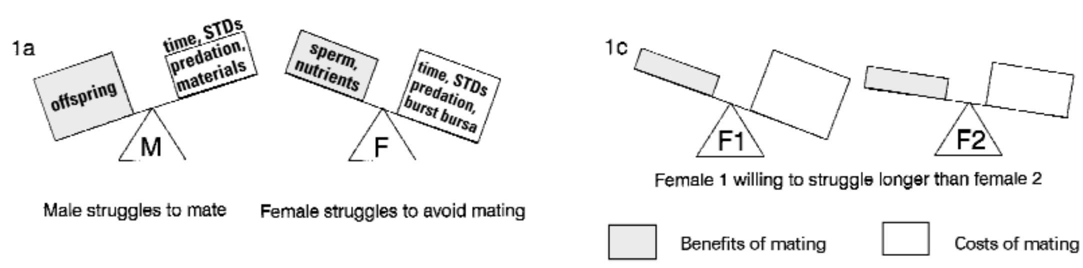
Introduction

Male coercion

Mating behavior in monarchs, especially the coercive behavior of males, presents a puzzle for biologists. This behavior has been described in detail elsewhere (e.g. Pliske 1975, Boppré 1993, Van Hook 1993, Frey et al. 1998, Frey this volume). Briefly, pre-copulatory courtship (behaviors that occur after the male has located the female and before the pair has coupled or separated without mating) has two phases. During the first phase males either pursue females in flight or pounce on resting females. During the second phase the male is in physical contact with the female and attempts to couple with her. The second phase can involve prolonged contact, during which females often show resistance behavior (Frey this volume). Unsuccessful mating attempts end when one individual leaves the attempt. Successful attempts result when the female stops using resistance behaviors or when the male succeeds in coupling with the female despite active resistance (Frey this volume). Copulations last up to sixteen hours and females cannot end a copulation once it has begun (Oberhauser 1989b). Monarchs are one of only a few lepidopteran species in which coercive mating has been described; most female Lepidoptera can reject courting males successfully and quickly (review in Rutowski 1982). The monarch is also unusual among its close relatives. Whereas most Danainae (milkweed butterflies) secrete pheromones (chemical signals) from hairpencils and alar wing pockets, and engage in complex courtship rituals, male monarchs employ a "take-down" strategy in which ritual behaviors and chemical cues appear to be unnecessary (Pliske 1975, Boppré 1993).

Intersexual conflict over mating has attracted both empirical and theoretical attention (e.g. Parker 1979, 1984; Hammerstein & Parker 1982, Clutton-Brock & Parker 1995, Choe & Crespi 1997). The conflict is manifested between individual males and females when females try to reject males because they have already mated, or could increase their fitness by mating with a different male or at a different time. However, the outcome of intersexual conflict is an evolutionary one. Males have won the evolutionary conflict when coercion, the use of force or threat of force by males to overcome female reluctance to mate (Smuts & Smuts 1993), is a mating strategy in a species. Once coercion evolves, females must either accept matings that could have negative effects on their fitness, or engage in costly behavior to reject males. Females have won the conflict when males respond to female signals of non-receptivity by giving up courtship attempts. Male coercion generally either occurs or doesn't occur in species, even though individuals may differ in the degree to which they use coercion as a mating strategy.

Figure 1a is a schematic presentation of the costs and benefits involved in matings. Males should only attempt to mate with unwilling females if the benefits of mating are likely to outweigh the costs. These benefits are the number and viability of offspring that are likely to result from mating, and their magnitude depends on female age, size and condition, and the probability and timing of female remating. Young females in good condition are likely to lay more eggs than older females (Oberhauser 1997), whereas a subsequent mating by the female will result in decreased male fitness, due to last-male sperm precedence (Oberhauser unpublished). The cost of mating for a male is any decrease in future reproductive success that results from the mating. Potential costs include lost time (while a male is mating with one female, he cannot mate with another, possibly more receptive or fertile, female), the possibility of contracting sexually transmitted diseases (e.g. Altizer et al. this volume and in preparation), the male's material investment, and increased risk of predation during mating. Because costs are weighed against future reproductive success, they will be relatively more important to males with higher future reproductive potential; selection favors investment in current reproduction over conserving resources for later reproduction when individuals have a low probability of surviving to reproduce later (Williams 1966).



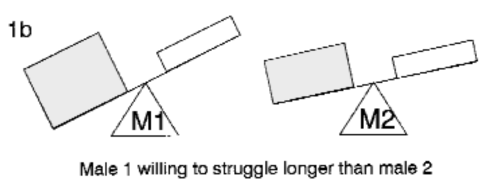


Figure 1a. The male should attempt to mate, even if the female is unwilling, since the benefits he would gain from mating outweigh the costs. The female should struggle to avoid mating, since the costs she would incur outweigh the benefits. Potential costs and benefits are represented in the figure (STDs = sexually transmitted diseases) 1b. Male 1 should be willing to persist longer in a mating attempt than Male 2, since his benefits outweigh his costs by more. 1c. Female 1 should be willing to struggle longer to avoid mating than Female 2, since her costs outweigh her benefits by more.

Females should struggle to avoid mating when the costs of mating outweigh the benefits they expect to gain (figure 1a). Female benefits include the sperm and nutrients passed in the spermatophore, and their magnitude will depend on the amount of nutrients received, the female's nutritional state, whether she has eggs ready to fertilize, and possibly the male's genetic quality. Potential costs include the time involved in mating (during which she cannot lay eggs or nectar), potential disease transfer, and risk of predation. In addition, females can suffer costs from mating too often; they can actually be killed if they receive so much spermatophore material that their bursa copulatrix ruptures (Oberhauser 1989a, Goehring & Oberhauser unpublished).

Mating attempts have costs for both individuals (e.g., energy, wing damage, predation risk, and time), which are separate from the costs of mating itself. The magnitude of these costs should increase in a roughly linear way with the time spent in the attempt. Males should desist in an attempt when its costs outweigh the expected net benefit of mating. Females should stop struggling and give in to the male when the costs of resisting the attempt outweigh the expected net cost of the mating itself (for a game theory approach to this process, see Clutton-Brock & Parker 1995). The more the male balance is tipped to the left (higher benefit to cost ratio), the longer the male should be willing to struggle to mate (Figure 1b). The further the female balance is tipped to the right (higher cost to benefit ratio), the longer the female should be willing to struggle (Figure 1c).

Mating during the overwintering period

The timing of mating during the overwintering period presents an additional puzzle for monarch biologists. Individuals in summer generations begin reproducing about five days after eclosion (Oberhauser and Hampton 1995), whereas reproductive tract development in the late summer/early fall generation is minimal and most individuals will not mate for several months (Herman 1985, Goehring and Oberhauser this volume). After a period of reproductive dormancy during the fall migration and overwintering period, diapause is terminated and a mass mating period is followed by remigration and reproduction in summer breeding grounds (e.g. Herman 1973, Brower 1985). Many of the hormonal and environmental cues that trigger these reproductive changes have been determined (Barker & Herman 1976, Goehring & Oberhauser this volume). However, there is both between- and within-population variation in the timing of diapause termination. The mass mating period in California appears to begin earlier, relative to dispersal from the colonies, and involve more individuals and more matings per individual than in Mexico (e.g., Tuskes & Brower 1978, Leong et al. 1995, Van Hook 1996). Some individuals begin mating sooner than others at the overwintering grounds (Van Hook 1993), and some mating occurs throughout the overwintering period in both Mexico and California (Van Hook 1996, this volume). Since mating incurs costs for both sexes, its occurrence days, weeks and even months before oviposition presents a puzzle.

Previous workers have addressed the puzzle of the timing of mating during the overwintering period. Van Hook (1993) suggested that males in poor condition begin mating first because they would have little chance of re-migrating. Alternatively, Wells et al. (1993) proposed that large colonies are actually an adaptation that increases the chances that females will survive the winter by facilitating nutrient transfer from males to females. Male monarchs, like other Lepidoptera, transfer a protein-rich spermatophore during mating (Boggs & Gilbert 1979, Oberhauser 1989a, 1992). The spermatophore is stored in the bursa copulatrix, a muscular organ within the female (Rogers & Wells 1984), and broken down by mechanical and chemical means into nutrients that have been traced to both female somatic tissue and eggs (Boggs & Gilbert 1979, Wells et al. 1993). Receiving nutrients from more than one male results in increased fecundity (Oberhauser 1989a, 1997), but male-derived nutrients have not been shown to increase survival prospects for overwintering females.

Here, we argue that it is likely that sexual coercion by male monarch butterflies evolved under the conditions experienced in the overwintering colonies, and that the solutions to the puzzles of male coercion and mating during the overwintering period are causally linked.

Methods

We studied mating attempts in the Sierra Chincua colony (Calvert & Brower 1986) in Michoacán (Mexico) and Pismo Beach State Park (Frey & Leong 1993) in California (USA). The work took place 24–28 February 1996 and 28 February–4 March 1997 in Mexico (about 3–4 weeks before colony dispersal, Van Hook 1996), and 17 January–8 March 1996 in California. We observed 276 attempts in Mexico, and 348 in California. We have divided California observations into early (17 Jan–12 Feb) and late (14 Feb–8 Mar) attempts because important characteristics (e.g., sex ratio and female mating status) of the colonies change as the season progress. All of these times are during the mass mating period (Van Hook 1993), and our study thus excludes matings before this period.

We studied male-female (all sites and times) and male-male mating attempts (Mexico and late California only) on an opportune basis, waiting for pairs to fall to the ground after contact was made in the air or as the female was resting in the canopy. We timed the total ground phase duration of each attempt and recorded its outcome. In Mexico in 1997 and in California, we placed net cages over pairs so that we could measure several characters of both individuals when an attempt ended. In Mexico, these included right and left forewing length, wing condition (on a scale of 1–5, with one being pristine condition and 5 being the highest level of scale loss), the number of wings with pieces missing (0–4), and an estimate of abdomen girth (on a scale of 1–3, with 1 being emaciated and 3 being adipose). We estimated whether the female had mated previously using abdominal palpation (Van Hook this volume) and assigned each female a value of 0 (no spermatophore felt), 1 (a small amount of spermatophore material), or 2 (a large amount of spermatophore material). This technique does not allow us to determine how many times the female has mated, but we can distinguish virgin females from mated females, and females with more than 25–30 mg of spermatophore material in their bursa from those with less material (Oberhauser unpublished, Van Hook this volume). Since spermatophore transfer generally does not begin until nightfall (Svärd & Wiklund 1988, personal observations), our palpations assessed previous matings, not the current one. We also used a non-destructive technique (Altizer et al. this volume) to determine whether individuals were infected with the parasite *Ophryocyctis elektroscirrha*. All butterflies in Mexico were then released. In California, we measured wet mass, right forewing length, the number of damaged wings, and the mass and number of spermatophores (see Frey et. al 1998) in female bursae for 122 pairs that were collected and immediately frozen. If we did not observe the beginning of an attempt, we recorded its outcome and the above individual characteristics, but not the total duration.

We also compared the above characteristics of mating individuals to butterflies that were roosting in the trees at the same time and in the same sites. These measurements were made at Sierra Chincua in Mexico in late February and early March, 1996 and 1997, and 1–6 February, 1997 at the Ellwood, San Leandro Golf Course, Moran Lake, Morro Bay Golf Course, and Pismo Beach sites in California. We did not compare mating and roosting butterflies late in the winter in California.

Results

There were no effects of year on attempt duration in Mexico, so duration data from 1996 and 1997 are combined. The numbers of attempts observed in each location, and summary statistics on these attempts, are shown in Table 1. The likelihood of successful attempts does not differ with location and time ($\chi^2 = 1.90$, d.f. = 2, p = 0.386); approximately one third of all male-female attempts result in a mating. The duration of successful and unsuccessful attempts were not significantly different in Mexico, but successful attempts were longer late in the season in California. Male-male attempts made up about one fourth of all attempts in Mexico and late in the season in California (we did not record male-male attempts early in the season in California), and their duration was statistically indistinguishable from heterosexual attempts.

Table 1 — **Success rate and duration of mating attempts**

Population	% Successful	Median Duration Successful (range)	Median Duration Unsuccessful (range)	% M/M (median duration, range)
MX	31	36^{a} (1–664)	55^{a} (2–1,708)	25 (59^{a}, 2–600)
CA early	29	70^{ab} (18–1,037)	59^{a} (5–1,800)	
CA late	36	120^{b} (18–1,459)	53^{a} (2–1,303)	28 (40^{a}, 5–1,380)

Note: All durations are given in seconds. Summary statistics on % successful and median durations refer to male/female attempts only. M/M = male/male attempts. We report median durations of attempts due to their skewed distribution (see Figure 2). Durations followed by the same letters do not vary at the 0.05 level of confidence (ANOVA of log duration, Bonferroni test).

Figure 2 shows the distribution of attempt duration (successful and unsuccessful combined, male-female only) in both locations. There is a highly skewed distribution that approximates a negative exponential; most attempts last less than a minute, but some persist for several minutes.

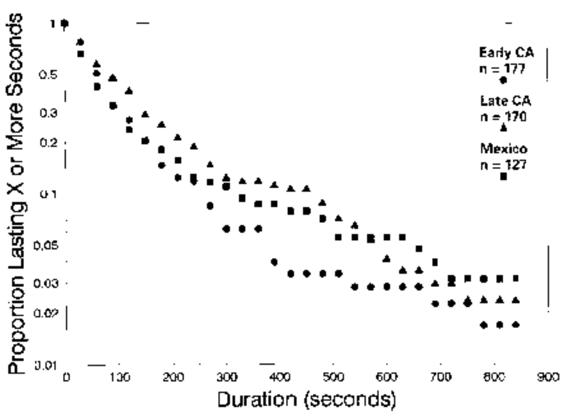


Figure 2. Distribution of mating attempt durations on a log scale. Successful and unsuccessful attempts are combined for each location, and only male/female attempts are shown. Each point represents the proportion of attempts in a given location that lasted at least the number of seconds shown.

In California, the mass of the intact bursa copulatrix was positively correlated with the log of attempt duration (n = 122; Spearman Z = 2.2, p = 0.028; Figure 3a). In Mexico, durations were longer when attempts involved females in which we palpated a spermatophore (Kruskall-Wallis one-way ANOVA of log duration on female mating status; mean rank virgin females = 16.6, mean rank mated females = 24.0, F = 4.53, p = 0.03, n = 36; figure 3b). There was no relationship between duration and female abdomen size, wing condition, or spore load in Mexico; or between duration and female mass, forewing length, or wing condition in California. There were no associations between any of the above traits in males and attempt duration in either Mexico or California.

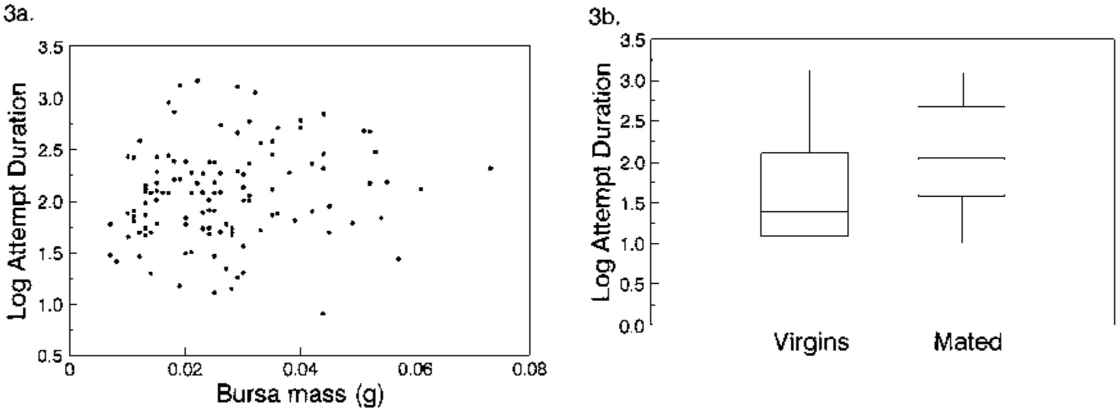


Figure 3a. Relationship between attempt duration (in California) and the mass of the female bursa copulatrix. Females with more material in their bursa are involved in significantly longer attempts.

Figure 3b. Box and whisker plot of attempt duration for mated and virgin females in Mexico (mating status determined by abdominal palpation). The boxes enclose the middle half of the data, lines bisect boxes at the median value, and whiskers indicate the range of data.

We also looked for associations between characteristics of individuals involved in attempts and the outcome of the attempts. There were no differences between individuals involved in successful and unsuccessful attempts in either location or in either sex.

Table 2 compares mating and roosting butterflies. 1996 and 1997 data from Mexico are combined, since there were no year effects on any measured characteristics. In Mexico, mating males had smaller wings, higher levels of wing damage and wing wear, smaller abdomen girth, and higher incidence of *O. electroskirrha* infection. In California, mating males were also smaller and more likely to be parasitized than roosting males. Mating males in California tended to have greater wing wear and damage than roosting males, but these differences were not statistically significant. Mating females in Mexico had longer wings than roosting females, and there was a marginally significant tendency for more mating females to have already mated than roosting females. There were no differences in wing condition between mating and roosting females. None of the characteristics we measured differed between mating and roosting females in California.

Table 2 — Comparison of monarchs collected mating and roosting

Population	Sex	Trait	Mating Mean	Roosting Mean	Test	Statistic	p
MX	male	abdomen	1.81	1.96	KW ANOVA	F = 10.2	0.001
		wing damage	2.98	2.29	2 sample T	t = 7.78	0.000
		wing condition	2.96	1.87	2 sample T	t = 9.93	0.000
		spore load	5.5% infected	1.1% infected	χ^2	$\chi^2 = 6.60$	0.037
		forewing	51.1	52.8	2 sample T	t = 4.87	0.000
	female	mated?	11% yes	4.3% yes	χ^2	$\chi^2 = 5.87$	0.053
		abdomen	2.13	1.96	KW ANOVA	F = 4.1	0.001
		wing damage	1.14	1.16	2 sample T	t = 0.11	0.913
		wing condition	2.39	2.37	2 sample T	t = 0.37	0.709
		spore load	1.7% infected	1.8% infected	χ^2	$\chi^2 = 0.00$	0.960
		forewing	53.0	52.1	2 sample T	t = 3.90	0.000

Table 2 (cont.) Comparison of monarchs collected mating and roosting

Population	Sex	Trait	Mating Mean	Roosting Mean	Test	Statistic	p
CA Early	male	wing damage	1.63	1.40	KW ANOVA	F = 1.94	0.164
		wing condition	2.95	2.86	2 sample T	t = 0.99	0.327
		spore load	32% infected	23% infected	χ^2	χ^2 = 6.44	0.040
		forewing	50.8	51.8	2 sample T	t = 3.11	0.002
	female	mated?	68% yes	68% yes	χ^2	χ^2 = 0.00	0.958
		wing damage	1.19	1.01	KW ANOVA	F = 0.64	0.423
		wing condition	2.84	2.89	2 sample T	t = 0.48	0.635
		spore load	24% infected	33% infected	χ^2	χ^2 = 2.60	0.270
		forewing	51.2	51.4	2 sample T	t = 0.31	0.750

Note: Sample sizes for Mexico: 145 mating and 188 roosting males, 145 mating and 236 roosting females; for California: 86 mating and 154 roosting males, 86 mating and 73 roosting females. “Infected” butterflies had a spore load of 4 or 5 (see Altizer *et al.* this volume). Forewing is the length of the left forewing in mm. See text for explanation of other characteristics.

Discussion

Male coercion in monarch butterflies

The duration and outcome of individual mating attempts in monarchs is affected by how long each individual is willing to persist in its attempt to mate (the male), or not mate (the female). In general, when the male is willing to persist longer, the attempt should result in a mating. Persistence time could be affected by whether assessment by either sex occurs during the struggle. If females use the attempt to assess male quality, they may persist longer with low quality males to avoid matings that could result in less fit offspring. Males might persist longer with high quality females.

The duration and outcome of mating attempts will also be affected by the degree to which each individual controls the struggle. A male clearly has control over an attempt if he forces an actively resisting female to mate. However, when the male ends an attempt without mating, it is difficult to determine which individual controlled the outcome. The male has control if he deserts or rejects a poor quality female. However, a male may also end an attempt because he has reached his persistence limit. In this case, the female has controlled the struggle because she has outlasted the male. One way to help distinguish between male and female control of unsuccessful attempts may be to assess female characteristics. In the case of male control, we would predict that short, unsuccessful attempts should be more common with poor condition females since these females should be most likely to be rejected. We would not expect the same relationship between duration and female condition if females control attempts by outlasting males.

Females clearly have control over attempts if they escape from the male. A successful mating, however, could result from female control if the female chooses or accepts the male because he is of high quality, or from male control if she accepts the mating simply because she has reached her persistence limit. As above, these two possibilities predict different associations between male traits and attempt duration and outcome. If females choose males, short, successful attempts should be more likely with males in good condition.

This study sheds light on how these factors might interact in monarch butterfly mating. Here, we argue that males and females weigh the costs and benefits of mating with little regard to the quality of their potential partner, and that the cost side of the cost/benefit balance is most important to both sexes.

Males with low prospects for future reproductive success, and thus a lower cost of mating, were more likely to be mating during the times that we studied overwintering monarchs. Those in poor condition (more wing damage, higher levels of infection by *O. electroskirrha*, and smaller abdomens) were over-represented in the mating pool, as were small males (table 2, see also Van Hook 1993, Frey et al. 1998). It is likely that these males would not survive to re-migrate (Alonso 1996), and even if they did, could be at a disadvantage during migration (Van Hook 1993, 1996). The fact that late-season mating attempts in California are longer than earlier ones (Table 2, Figure 2) supports our cost/benefit explanation, since future reproductive potential should be negatively correlated with male age. The lack of relationship between any potential measure of female quality and attempt duration suggests that the benefits that males can expect to incur from mating do not affect the time they are willing to struggle. However, longer struggles late in the season in California could result from higher expected payoffs to males; egg-laying is likely to occur sooner after late season matings due to host plant availability.

Figure 4a illustrates the cost/benefit trade-off for overwintering males. M1, M2 and M3 represent males in progressively poorer condition. We have set the benefits of mating equal for all three males, but the costs they would incur differ due to variation in future prospects. M1 should delay mating until it would result in higher payoffs, but the net value of mating is positive for M2 and M3, since their future prospects are lower. M3 should struggle longer than M2, since he has the least to lose.

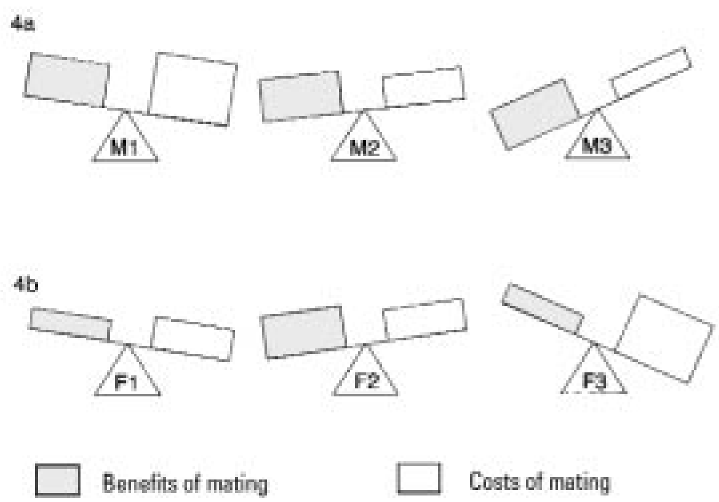


Figure 4a. Male 1 should not attempt to mate, since his costs outweigh his benefits. Male 2 will try to mate, but not for very long, since he would gain only a small net benefit from mating. Male 3 should be willing to struggle for longer. Each male expects to gain the same benefits, but they pay different costs in terms of compromised future reproductive success. They could represent overwintering males in progressively poorer condition.

Figure 4b. Female 1 should struggle to avoid mating, but not for long, since the costs of mating do not outweigh the benefits by much. Female 2 would benefit from mating, so should not struggle. Females 1 and 2 could represent virgin females (hence low cost of mating) in overwintering and breeding populations, respectively. Female 3 should struggle harder to avoid mating, since she would suffer a large net cost; she could represent a mated female in an overwintering population.

The fact that previously-mated females and females with more material in their bursae were involved in longer attempts (figure 3) suggests that costs of mating are also important to females. Mated females can incur a ruptured bursa copulatrix that will result in death when they remate (Oberhauser 1989a, Goehring & Oberhauser unpublished). We propose that this cost makes mated females willing to struggle to avoid mating. This, along with decreased costs of mating for late-season males (see above), could explain the longer late-season mating attempts in California (Table 1), when more females have mated (Leong et al. 1995, Frey et al. 1998). Another possible, but untested, cost for females is the additional weight of an unnecessary spermatophore during re-migration. Several lines of evidence suggest that the benefit side of the cost/benefit trade-off is not important to overwintering females. Females might be expected to benefit most from mating with a large male in good condition, due to a larger nutrient donation (Oberhauser 1988), or because these males might transmit higher fitness to their offspring (e.g., Charlesworth 1987). However, male condition was correlated with neither the duration nor the outcome of attempts (see also Van Hook 1993), and mating males represented a small, poor-condition subset of the male population (Table 2, Van Hook 1993, Frey et al. 1998). Another benefit that may be important to female is the male nutrient donation; Wells et al. (1990, 1993) suggested that an increase in female lipid reserves in late winter was due to male-derived nutrient. However, Van Hook (1996) presents evidence that increased female lipid levels are not due to the observed level of mating, but instead are more likely to result from differences in energy budgets or nectaring behavior

(Van Hook 1996 and personal communication). Additionally, if male-derived nutrients are important, thin females should be over-represented in the mating pool, since they should benefit most from receiving lipids from males. If anything, the opposite is true (Table 2, Van Hook 1993). Finally, it is probably not critical that females obtain sperm during the overwintering period, since they are likely to have ample opportunity to mate when they are ready to lay eggs.

Our results suggest that males do not have complete control over the outcome of mating, as previously implied by many authors (Urquhart 1960, Pliske 1975, Rothschild 1978, Van Hook 1993). Females often exhibit behaviors that decrease the likelihood that the attempt will end in coupling (Frey this volume), and approximately 70% of all attempts do not end in coupling (Table 1 and Frey this volume). In addition, male mate choice does not appear to be important during mating attempts. The only female characteristic correlated with attempt duration was mating history, with mated females more likely to be involved in long attempts. If anything, mating with a previously-mated female might be expected to result in lower payoffs due to sperm competition. Traits that might indicate female quality, such as size (e.g., Oberhauser 1997, Alonso et al. 1997) and wing condition, were not correlated with attempt duration or outcome (see also Van Hook 1993). The fact that mating females were larger and fatter than roosting females in Mexico (Table 2, Van Hook 1993) could result from variation in female activity or apparency, or active male discrimination (see Van Hook 1993). In any case, the duration and frequency of male-male attempts suggests that males do not carefully assess their partners before or during attempts.

Overwintering and the evolution of male coercion

At the last international monarch butterfly conference, Boppré (1993, p. 38) said that "we have as yet no meaningful hypothesis as to what might have caused the American monarchs to adopt such a modified mating strategy." We suggest that this strategy evolved in the context of overwintering, in which there is a prolonged adult non-reproductive period followed by costly remigration. Male coercion should only evolve when the net gain to males of mating with reluctant females is greater than the net loss of unwanted matings to these females. If this condition is not met, selection on females to avoid mating will be stronger than that on males to mate, and females should evolve effective ways to avoid unwanted matings (e.g., Parker 1984). We propose that it is in the context of overwintering that this condition is most often met. At the overwintering sites, especially at the end of the season, many butterflies have used much of their lipid reserve, and there is little chance that they will survive to remigrate and reproduce (Wells et al. 1993, Alonso et al. 1997). When this is true of males, their best strategy may be to attempt to mate at the overwintering sites. Even though the fitness gains they can expect from these matings are likely to be low, their poor condition means that the net benefit of mating will be relatively high. The fact that sperm survive for several weeks in the female (Oberhauser 1997) means that there is a chance that some sperm from early matings may be used to fertilize eggs once females become reproductive.

Females may not gain a great deal from winter matings, but they also may not lose a great deal, unless they have a large amount of spermatophore material already present in their bursa copulatrix. We suggest that overwintering females are, in general, reluctant to mate because they receive few benefits, and incur some costs. Thus, many overwintering females are like F1 in Figure 4b: they do not struggle very long because the costs of the struggle soon outweigh the costs of mating. In the summer, females are more likely to either benefit from mating (since they use sperm and male-derived nutrients in reproduction, e.g., F2, in Figure 4b), or to incur very high costs, since mating when they need neither sperm nor nutrients results in a cost of lost time for egg-laying in addition to the risk of a ruptured bursa copulatrix (e.g., F3, in Figure 4b). The condition required for the evolution of male coercion may not be met often in the summer when females are more likely to be either willing to mate or would lose a great deal by mating. We propose that the overwintering co-occurrence of females with cost/benefit balances like F1 and males like M3 in Figure 4 fulfill this condition. It is only in the overwintering colonies that reluctant, but fertilizable, females with little to gain by mating, but often relatively little to lose either, co-occur with males with few future reproductive options. Once coercion evolved in this species, it became a mating strategy that was used in both overwintering and summer generations, and the dependence on chemical cues was lost.

Future research directions and implications for conservation

Many predictions of our hypothesis are untested, and we would like to suggest research directions for monarch biologists interested in reproductive behavior. Our hypothesis predicts that payoffs to either sex from mating during the overwintering period will be low, but almost nothing is known about these payoffs. They will depend on the magnitude of nutrient donations by overwintering males, the ability of females to utilize male-derived nutrients for increased survival or fecundity, mating opportunities for females after they leave the overwintering colonies, and the extent to which females use sperm received during the overwintering period. In addition, we do not know the proximate causes for the variation in the timing of mating among males, nor the relationship between oogenesis and female mating in the overwintering colonies. Finally, we need to make the same kinds of observations as described above and by Frey (this volume) in breeding populations, even though low population densities will make these observations more difficult.

Our results and proposed research directions may seem to have little relevance to conserving this amazing butterfly and the endangered phenomenon (Brower & Malcolm 1991) of its migration, but we argue that they do. If our hypothesis is correct and mating in the winter is costly to females, increased mating frequency will result in decreased average female fitness, and the health of a population will suffer if mating by overwintering butterflies becomes more common. Males in poor condition are overrepresented in the overwintering mating pool (Van Hook 1993, Frey et al. 1998, this study), suggesting that a decrease in average male condition is likely to lead to more early mating. The frequency of mating during the overwintering period may be both an indicator of overall population health and a cause of compromised population health; there may be a cascading series of linked conditions beginning with compromised male condition leading to increased mating in the overwintering colonies, decreased female fitness, and finally a compromised spring remigration. This suggests another productive avenue for future research—determining why mating occurs with greater frequency in California overwintering sites, and how mating affects the timing of female dispersal. The above scenario would predict that butterflies in the western population are in poorer condition. They certainly have higher parasite burdens (Altizer et al. this volume), and it could also be that warmer average conditions throughout the overwintering period accelerate lipid use and butterfly aging (Chaplin & Wells 1982, Alonso et al. 1997). In any case, it is possible that the increasingly male-biased sex ratios in California colonies result from females leaving the colonies sooner that they would otherwise due to male harassment. We do not know where females go when they depart from the colonies, nor how fitness is related to the timing of female departure.

Many factors will affect male condition, including the abundance and quality of larval food supply, nectar availability during the fall migration, and conditions in the overwintering sites. These factors are likely to be linked in a myriad of ways to overall population health, making every bit of knowledge potentially important in informing monarch conservation efforts.

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Resistance to mating by female monarch butterflies

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Abstract
Male monarchs (*Danaus plexippus* L.) capture overwintering generation females either by landing on them in mid-flight or by pouncing on them while perched on vegetation at the site. After falling to the ground they attempt to attach to the female, using abdominal claspers. These coupling attempts often involve struggles between male and female. This study examined the dynamics of monarch mating episodes at a central coast California overwintering site (San Luis Obispo County). Females used several behaviors to resist male coupling attempts. These behaviors often impaired male access to the female's abdomen tip and reduced coupling probability. The most effective type of resistance used by females involved curling the tip of the abdomen forward under the thorax and head. This behavior increased in frequency as the mating season progressed in association with increased male mating effort, was never observed in virgin females, and was more likely to occur among multiple mated females when their bursa copulatrix contained cumulative spermatophore mass in excess of 13 mg. I suggest that these patterns result from a mechanical triggering of this behavior by a "full" bursa copulatrix, increased bursa content mass later in the season, and possible costs of the behavior.

Introduction
Following a two-to-four month relatively inactive overwintering phase, monarch butterflies (*Danaus plexippus* L.) at central coast California (USA) sites begin an intense period of reproductive activity (Hill et al. 1976; Tuskes & Brower 1978; Frey et al. 1998). Mass mating activity typically starts by mid-January and continues through late February and early March, when population abundance decreases due to dispersal from overwintering aggregations (Hill et al. 1976; Frey & Leong 1993; Leong et al. 1995; Frey et al. 1998). The majority of California overwintering sites have male-biased sex ratios (Nagano et al. 1993; Frey & Leong 1993, 1995) and females tend to disperse sooner than males (Frey et al. 1998). The combination of large aggregations of individuals, a relatively short mating period and the above noted demographic trends set the stage for sexual selection to influence reproductive processes (Wade & Arnold 1980; Clutton-Brock 1988; Andersson 1994).

Male monarchs mate at overwintering sites by progressing through four relatively distinct behavioral phases. First, they must locate or encounter a potential mate. They may do this by leaving overnight clusters slightly earlier in the morning than females and pursuing them in the air space near roosting trees (Lisa Falco, unpublished data). Male monarchs have been categorized as using "patroller" type mate-locating behavior, since they fly about attempting to locate or attract females (Scott 1974; Rutowski 1991; Wickman 1992). However, they also exhibit a "percher" type mate-location behavior as they sometimes dart out from resting locations on canopy vegetation to pursue passing females (personal observations). In the second mating phase the male tries to capture a female using one of two basic tactics. He either attempts capture while both are in flight (Urquhart 1960; Pliske 1975) or pounces onto a female that is resting in the canopy (Leong 1995; personal observations). During the third phase, the coupling phase, the male attempts to couple with the female by clamping onto her terminal abdomen segment with claspers that are located on the tip of his abdomen (Pliske 1975; Frey et al. 1998). Phase four involves a nuptial flight, in which the male flies with the attached female to a nearby canopy location (Shields & Emmel 1973), and spermatophore transfer which takes place some time after nightfall (Svard & Wiklund 1988; Oberhauser 1989).

The coupling phase of monarch mating sequences often has the appearance of conflict and struggle between the male and female (Frey et al. 1998; personal observation). Early descriptions of the behavioral events and processes during this stage often included terminology that was anthropomorphic and/or strongly gender-biased. Males were said to "dismiss" and "desert" females during courtship (Pliske 1975). Females were referred to as "passive" and the "quarry" and males supposedly "strut" in front of females to entice them to cooperate (Urquhart 1960). Females that failed to respond to male courtship were categorized as exhibiting "apathy" (Pliske 1975). Use of these terms can be misleading, suggesting causality without sufficient evidence.

I studied the ground phase pre-coupling mating activity (i.e., the third stage in the mating sequence given above) of monarch butterflies at a central coastal California overwintering site. The primary goals of this research were to: 1) develop operational descriptions of behavioral events and states used by both sexes , and 2) establish proximate-level cause and effect relationships among these behaviors, particularly among activities that may constitute resistance behavior by females during coupling attempts. This kind of study is an important first step toward understanding the forces behind mating dynamics and the forms of sexual selection that are associated with the mating system of monarch butterflies.

Methods

This study was done at a monarch butterfly overwintering site in North Beach campground of Pismo Beach State Park, Pismo Beach, California (San Luis Obispo County, USA; 35º07´46˝ N, 120º 37´53˝ W; see Frey & Leong 1993, for a complete description of the site). The 1.4 ha area is dominated by blue gum (*Eucalyptus globulus* Labill.), with scattered Monterey cypress (*Cupressus macrocarpa* Hartw.), and Monterey pine (*Pinus radiata* Don) and very little understory is present.

During the 1994 mating season (January to March), I made video recordings of the ground-phase of 60 mating episodes and identified four female postures that appeared to constitute resistance to male coupling attempts (Table I). In all four postures the tip of the female abdomen is displaced to an unusual position so that it is "protected" from the male as he probes with his abdomen tip. Between January 17 and March 8, 1996, I recorded data from 348 mating episodes during 20 site-visits at two-to-three-day intervals. Data were recorded between 09:30 and 16:00 PST. After males successfully captured a female, I timed the duration of each mating episode from the moment they reached the substrate until either pair member departed or until the male successfully clamped onto the female. For each episode I also recorded: 1) each time the female exhibited one of these potential resistance behaviors, 2) the outcome of each episode (i.e., male coupled or did not couple), and 3) which sex left or broke off first in cases in which the pair did not couple.

Table 1 — **Descriptions of body positions that may constitute female monarch butterfly resistance to mating**

Position	Description
Inverted	Female body positioned with ventral surface facing upward (or outward); wings held horizontal with hind wings overlapped and abdomen dorsal to wings.
Arch	Female flexed abdomen dorsally away from major axis of the body at an angle of approximately 30 to 90 degrees; wings may be horizontal or folded dorsal over the mid-line of the body.
Sheath	Female folded wings over the mid-line of the body; usually lay tilted to one side against the substrate, vegetation, or debris; abdomen positioned between dorsal surface of tightly closed wings.
Curl	Female bent abdomen forward to a ventral position under her thorax; often grabbed abdomen tip with legs.

Mating activity was greatest in four or five localized areas within the bounds of the site. Each date, I recorded several episodes from one area, then moved to another in order to minimize the likelihood of recording mating attempts that involved the same individual. Because the population abundance was large (i.e., declined from 140,000 at the onset of the study to fewer than 1,000 individuals by the end of the study;

Jolley-Seber mark-release-recapture estimates, Frey unpublished data), the chance of recording the same individual more than once was unlikely.

On 17 of the 20 visits, approximately every third pair was collected after the outcome of their episode had been established (N= 122). Those in copula were carefully separated and each individual was placed in a plastic freezer container and held in an ice chest until they were frozen (-20ºC). To assess female prior reproductive history, the bursa copulatrix of each was removed and weighed (wet weight) and then dissected. The spermatophores present were counted and the largest one was weighed and its diameter was measured.

Results

Of the 348 phase-three coupling attempt episodes, 32.5% (113) ended in coupling. In 229 of the 235 episodes in which coupling did not take place, one partner clearly was the first to leave. Which partner left first was independent of sex, males departing first 52% of the time (χ^2 = 0.14, df = 1, P = 0.708).

Female monarchs carried out all four putative types of resistance behavior described in Table 1 during the study, sometimes exhibiting more than one of them during a single mating attempt. Overall, in 82.8% of the episodes, some form of resistance occurred and females deployed 1.32 ± 0.04 (mean ± SE) different kinds of these behaviors per coupling attempt (Table 2; columns b & c).The most frequently deployed female putative resistance was inverted body posture. The female either landed in an inverted position or flipped upside down upon contacting the ground in 54% of the mating episodes. Females tightly sheathed or folded their wings around the tips of their abdomens during 32% of the coupling attempts. They curled their abdomens ventral and forward under their thoraxes in 9% of the attempts. In 38% of the episodes, females arched their abdomens upward 30 to 90º relative to the orientation of their thoraxes. This posture occurred during 51% of the inverted state occurrences and during 29% of wing sheathing occurrences. In the majority of attempts, regardless of which posture the female deployed, the male was much more active than the female, frequently changing positions, crawling over her, and carrying out strong downward flexion with his wings in addition to probing movements with his abdomen tip.

Table 2 Distribution of mating episodes grouped by number of different resistance behaviors per episode and descriptive statistics for each group

(a) Number of resistance behaviors	(b) Frequency[a]	(c) %	(d) Episodes ending in mating[b]	(e) % episodes ending in mating
none	60	17.2	37 (19.5)	61.7
one	140	40.2	44 (45.5)	31.4
two	125	35.9	26 (40.5)	20.8
three or four	23	6.6	6 (7.5)	26.1

Note: Means with unique subscripts differed significantly; ANOVA F = 23.8, df = 3, 342, P = 0.0001; Scheffe F-tests, P<0.05.

[a] Distribution departs from a Poisson pattern; χ^2 = 38.97, df = 3, P<0.0001

[b] Expected values (shown in parenthesis) are based on distribution in “frequency” column; contingency analysis, χ^2 = 31.6, df = 3, P = 0.0001.

A two-way contingency analysis of the total number of different kinds of putative resistance behavior used per episode (i.e., none, one, two, or three to four) verses outcome (mated or not mated) indicated lack of independence (Table 2; χ^2 = 31.6, df = 3, P = 0.0001). Encounters with no resistance activity were more likely to end in coupling, i.e., about 62% of the time, while those with one or more types of resistance were less likely to end in mating (Table 2; column d).

The relationship between the use of each of these four behaviors (i.e., inverted, arch, sheath, or curl) during a mating episode and the episode outcome (i.e., whether it ended in no coupling or coupling) was also each tested separately by two-way contingency analysis. Since at least one of the resistance types had a seasonal pattern (see below) and because other seasonal differences in mating patterns had been reported previously (Hill et al. 1976; Van Hook 1993, 1996; Frey et al. 1998), I analyzed the episodes from the first half of the season (17 January to 12 February) separately from the second half (13 February to 8 March). During the initial weeks of the mass mating season, episodes in which females had either inverted their body or arched their abdomen were less likely to result in coupling (Table 3, a & b). Abdomen curl rarely occurred during the first four weeks of the season (see below) and it was the only activity that resulted in significant reduction in coupling probability during the second half of the season (Table 3, c).

Table 3 Tests of independence between specific resistance types and episode outcome

Numbers in parentheses are percentages of episodes where coupling either did or did not occur.

a. Early season episodes involving inverted postures by the female

	Resistance posture	
Outcome	*Not Inverted*	*Inverted*
Not coupled	40 (57%)	86 (80%)
Coupled	30 (43%)	22 (20%)

Note: $\chi^2 = 9.3$, df = 1, P = 0.002

b. Early season episodes involving arching postures by the female

	Resistance posture	
Outcome	*No Arch*	*Arched*
Not coupled	66 (63%)	59 (81%)
Coupled	38 (37%)	14 (19%)

Note: $\chi^2 = 5.4$, df = 1, P = 0.02

c. Late season episodes involving curl postures by the female.

	Resistance posture	
Outcome	*No Curl*	*Curled*
Not coupled	87 (60%)	22 (85%)
Coupled	57 (40%)	4 (15%)

Note: $\chi^2 = 4.6$, df = 1, P = 0.03

The proportion of mating episodes ending in coupling did not differ between the first half and second half of the mating season (first half coupled: 30% and second half coupled: 36%; $\chi^2 = 1.47$, df = 1, P = 0.225). However, in addition to the seasonal trends pointed out above, three other patterns of change occurred. The first pattern, displayed in Figure 1, involved changes in the seasonal occurrence of each of the four kinds of putative resistance behavior used in mating episodes. Three types of resistance (inverted body, wing sheathing, and abdomen arching) were consistently observed throughout the mating season. Their lack of occurrence on particular dates was probably due to small sample sizes (e.g., on day 8 and 13, arched abdomen and sheath respectively were not observed, however only nine and five mating episodes were recorded on each of these dates). In contrast, abdomen curl was not observed until day 17 of the study and occurred on only three dates during the first half of the season, but was observed during each of the visits during the second half of the season. Of the 30 episodes in which the curled abdomen posture was observed, four cases (13%) occurred during the first half of the mating season while 26 (87%) occurred during the second half of the season.

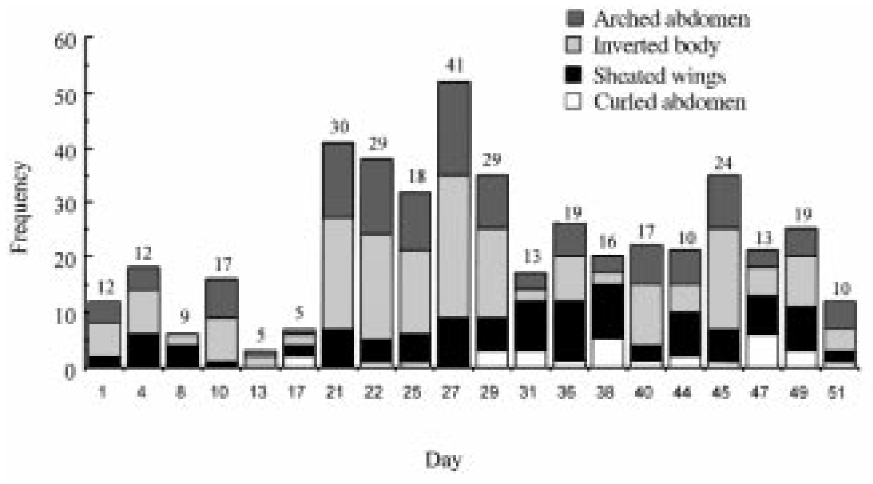

Figure 1. Seasonal pattern of the four kinds of putative resistance activity exhibited by female monarch butterflies. Day refers to days since Jan. 17, 1996. Number above each histogram = total sample size.

The per capita frequency of mating attempts also changed over the season. An estimate of the rate of mating attempts was computed by (1) dividing the number of mating episodes recorded on a given day by the amount of time I spent searching for ground-pairs, and (2) adjusting the number of episodes recorded/min by the number of females at the site (number of females for each date were available from Jolly-Seber population estimates, Frey unpublished data). The seasonal pattern of this index is shown by Figure 2. Mating attempt rate was positively correlated with date since mating season began (Spearman's correlation $Z=3.7$, $N=20$ $P=0.0002$).

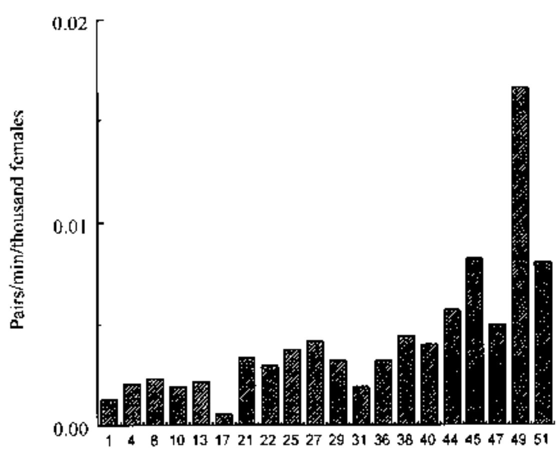

Figure 2. Seasonal pattern of mating attempts per capita (number coupling attempts/min./1,000 females). Day refers to days since Jan. 17, 1996.

A third seasonal pattern was revealed from analyses of mating histories of females dissected from the subset of females that were collected. The bursa copulatrix of these females weighed more and contained more spermatophores as the season progressed (Spearman's correlation, $Z=6.4$, $N=118$, $P=0.0001$ and $Z=6.6$, $N=120$, $P=0.0001$ respectively). The seasonal pattern of increasing bursa mass and spermatophore number is shown in Figures 3a and 3b respectively. However, the mass of the largest spermatophore present in the bursae of previously mated females did not differ significantly over time; nor did the greatest diameter of the largest spermatophore (Spearman's correlation, $Z=1.0$, $N=93$, $P=0.3$ and $Z=0.8$, $N=93$, $P=0.43$ respectively).

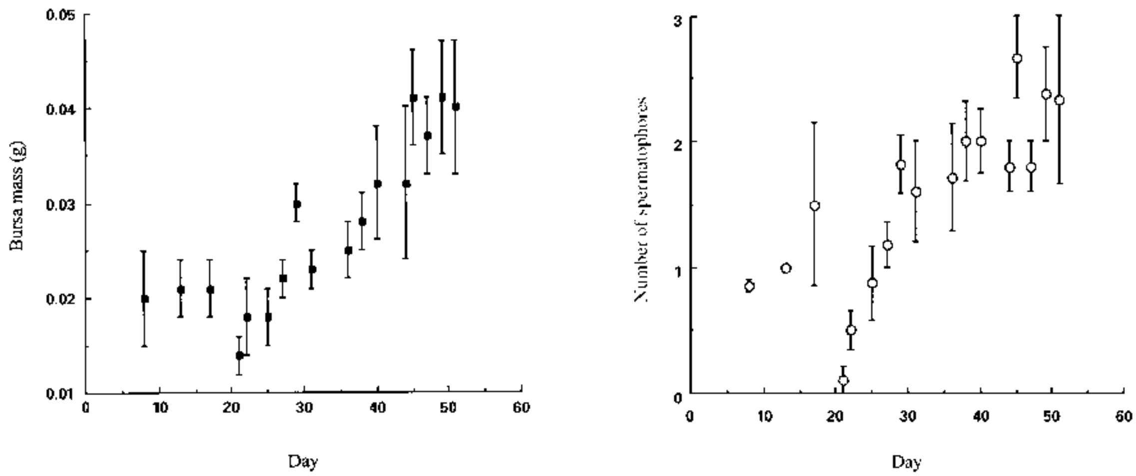

Figure 3a. Seasonal pattern of mass of bursae (mean ± S.E.).
Figure 3b. Seasonal pattern of number of spermatophores present in bursae (mean ± S.E.). Day refers to days since Jan. 17, 1996.

The bursae of females that curled their abdomen forward under their thorax during a mating attempt were heavier than those that did not show this behavior (Mann-Whitney, $Z = -2.78$, $P = 0.005$, mean ± SE: 33 ± 3 mg vs. 25 ± 1 mg, $N = 19$, 99 respectively). These females also had more spermatophores present in their bursa (Mann-Whitney, $Z = -2.44$, $P = 0.015$, mean ± SE: 1.90 ± 0.17 vs. 1.34 ± 0.11, respectively). The diameter of the largest spermatophore in the bursa of females from the group exhibiting abdomen curl was also significantly greater than that for females that did not curl their abdomen ventral (Mann-Whitney, $Z = -2.15$, $P = 0.03$, $N = 75$, 18; 2.51 ± 0.14 mm vs. 2.25 ± 0.08 mm, respectively). None of the other resistance activities had relationships with bursa and spermatophore variables. None of the virgin females, i.e., those without spermatophores in their bursa, exhibited curl resistance.

Discussion

Conflict of interest between the sexes may exist at each stage of a mating attempt (Brown et al. 1997; Clutton-Brock & Parker 1995). Struggling between male and female monarch butterflies during the coupling phase of reproduction probably reflects this sexual conflict of interest (Oberhauser & Frey this volume). Analyses of reproductive activities involving conflict of interests often center on resistance by females and persistence by males. Resistance and persistence are the result of specific behavioral components of mating attempts that have rarely been subjected to detailed description and analyses. In this study, I identified and described four specific putative resistance behaviors exhibited by female monarch butterflies during coupling attempts by males. Three of these behaviors decreased the probability of coupling, and can thus be operationally defined as resistance behavior. Female monarchs often resisted male mating attempts in the coupling phase; over 80% of all mating episodes in this study involved one or more resistance acts. When females did not exhibit resistance, 62% of the ground phase attempts resulted in successful male coupling. Males coupled only 26% of the time however when females used some form of resistance. Mating attempts in which females used inverted body posture, arched abdomen, and curled abdomen (but not sheathed abdomen) had significantly reduced coupling probability (Table 3, a, b, c). This was true for episodes with inverted postures and arched abdomens only during the first half of the mating season. Curling the abdomen forward under the thorax and head was the least frequently used type of resistance. It was, however, the most effective form of female resistance, reducing coupling probability by 50% overall (i.e., coupling probability was 0.341 in the absence of abdomen curling and 0.167 in episodes in which curl occurred) and coupling probability was reduced by over 60% during the last half of the season (Table 3, c) when it most often occurred (Figure 1). It was during the second half of the mating period when females were subject to increased per capita mating attempts (Figure 2). The occurrence of three different kinds of resistance is not surprising since alternative reproductive tactics occur widely among insects during various stages of mating activity, although most other studies focus on male behavior (see for example: Shreeve 1984; Rutowski 1991; Alexander et al. 1997; Zuk & Simmon 1997).

Movement of the abdomen by females during mating attempts, similar to the abdomen arch observed in this study, have been mentioned previously in studies of *D. plexippus* (Hill et al. 1976), as well as in *Anthocharis cardamines* (Wiklund & Fosberg 1985) and *D. gilippus* (Brower et al. 1965). Pliske (1975) noted that pairs of monarchs sometimes fall to the ground with the female upside down, a posture that was probably equivalent to inverted posture described here. In one form of monarch resistance (inverted body posture), females appeared to limit access to their abdomen tip by shielding it with their overlapping hind-wings. An analogous situation exists in the pupal mating butterfly *Heliconius hewitsoni*, where males use their wings to shield female pupa from other competing males (Deinert et al. 1994).

Sugawara (1979) identified stretch receptors in the bursa copulatrix of the butterfly *Pieris rapae* which, when stimulated by a large spermatophore, triggered female mate refusal behavior. Dedicated mechanical control systems for female resistance have also been inferred in another Lepidoptera, *Euphydryas editha* (Labine 1964) and in the grasshopper, *Gomphocerus rufus* (Loher & Huber 1966) by severing afferent pathways from the bursa. Summer generation monarch females held in outdoor cages and mated to males producing large spermatophores, i.e., 30–37 mg, had significantly longer intermating intervals compared to those that received small ones, i.e., 7–15 mg (Oberhauser 1988,1989). I found that female monarchs that exhibited abdominal curl had 32% greater bursa mass than females not showing this posture. They also had mated more often previously and had larger spermatophores than females not displaying curl resistance. These relationships are consistent with mechanical control of this behavior. Furthermore, data presented here suggest that the threshold of spermatophore mass within the bursa required to elicit abdominal curl resistance exists between 13 mg and 21 mg, i.e., the average intact bursa mass of the females that did not use abdomen curl (25 mg, N = 101) and those that did (33 mg, N = 19), minus the average bursa mass of virgin females (average = 12.0 mg, N = 23).

Of the three types of female resistance behavior that clearly reduced male mating success (inverted posture, arched and curled abdomen postures), why do females use the most effective type (curled abdomen) infrequently? The bursa copulatrix of most non-virgin females did not contain large spermatophores, i.e., ones likely to trigger abdominal curl response. Among the females that had mated at least twice, 60.4% of them had a most recent spermatophore with a mass of 7 mg or less while only 7.5% had one larger than 14 mg. Early female departure leads to an increasingly male biased operational sex ratio at this site (Frey & Leong 1995; Frey et al. 1998). If total on-site matings (approximately 2.2 matings per female in this study) were distributed uniformly among all males over cumulative female-days of mating, they would result in average intermating intervals for males of at least eight days. Spermatophore mass that a male monarch can produce increases with time since his last mating (Oberhauser 1988) and intermating intervals of this magnitude should theoretically result in males producing spermatophores greater in mass than the abdominal curl threshold predicted above. However, overwintering males may transfer small spermatophores at California overwintering sites because the same ones are mating repeatedly while others seldom mate. Several lines of evidence suggest that variance of male monarch mating frequency is extremely high at California monarch overwintering sites, as it is in other Lepidoptera (e.g., Elgar & Pierce 1988). First, mating males given unique identifying marks at this site were recaptured in subsequent mating episodes much more often than their marked female partners, i.e., a pattern opposite of one predicted from uniformly or randomly mating males in a population with a male-biased operational sex ratio (Frey, unpublished data). Second, mating males had greater wing damage than males captured from the general clustering population and this was probably due to their involvement in more frequent and vigorous mating struggles (see Oberhauser & Frey, this volume). Third, among populations of caged summer generation monarchs, males had much greater variation in mating frequency than did females and males did not delay re-mating until they were able to generate a relatively large spermatophore (Oberhauser 1988, 1989). In addition, abdomen curl posture may occur less frequently due to higher costs associated with its performance than the other forms of resistance. This posture is frequently maintained by the female for several minutes even after male departure.

Why were inverted body posture and arched abdomen effective forms of resistance early but not later during the mass mating season? Both are general forms of resistance that are used by both sexes in additional avoidance contexts, for example they are used by both sexes along with forceful downward wing flexion when attacked by yellow jackets, *Vespula vulgaris* (Frey, personal observations). These more generalized postures may not afford a constant "level of protection" later in the season when male effort increases (Fig. 2), whereas abdomen curl resistance may effectively deter male coupling attempts regardless of variation in male mating effort.

Studies of mating patterns have historically emphasized male-perspective (for reviews on this issue see Ahnesjo et al. 1993; Small 1992). Brown et al. (1997) points out that females have often been regarded as "... passive players" in many models of mating pattern and sexual selection. However, the present study shows that female monarchs often use several types of behavioral resistance during mating attempts and strongly suggests that male mating pattern at California overwintering sites is influenced by this resistance.

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Environmental induction of reproductive diapause in *Danaus plexippus*

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Abstract

Each fall, eastern North American monarch butterflies emerge in a state of reproductive diapause and migrate long distances to overwinter in Mexico, delaying reproduction until the following spring. We examined the natural incidence of reproductive diapause in local populations of monarchs and studied the environmental cues that trigger this physiological response. Throughout late August and early September, adult monarch butterflies captured from the wild showed progressively less reproductive development; females were more likely to lack mature oocytes and males had smaller ejaculatory ducts. Larvae reared outdoors showed the same progression. Experimental rearing conditions of decreasing daylength, a fluctuating temperature regime and older hostplants, chosen to mimic natural conditions during the time that wild populations enter diapause, resulted in significantly greater proportions of diapause adults. Combinations of two of these cues were more effective in inducing diapause, even though single cues did result in some diapause adults. These results suggest there is within population variation in response to environmental cues.

Introduction

Organisms living in temperate regions face seasonal challenges, such as absence of food and harsh winter conditions. Another significant challenge imposed by the periodic decline of habitat is that of synchronizing reproduction with the availability of food in the breeding habitat. Insect adaptations to these challenges include seasonal migration, dormancy in various life stages, and seasonal polyphenism; various combinations of these traits constitute a diapause syndrome (Tauber et al. 1986).

The monarch butterfly (*Danaus plexippus*) is a tropical species that has expanded its range north into temperate regions, taking advantage of the distribution of its hostplant genus, *Asclepias* (Brower 1985). North American monarchs escape harsh winter conditions through long-distance migration (Urquhart and Urquhart 1978) and delay reproduction until the following spring, entering a state of reproductive diapause where reproductive tract development is minimal (Herman 1973, Brower et al. 1977). Eastern North American monarchs that migrate to overwintering sites in central Mexico remain in this condition four to five months before diapause is terminated and adults migrate north again. Monarchs in other areas (e.g., Australia and western North America) diapause to a lesser degree (James 1993; Tuskes and Brower 1978). In Australia, for example, monarch ovarian dormancy is more accurately classified as oligopause, an intermediate dormancy between quiescence and diapause that lacks the refractory period associated with diapause (James 1982).

Diapause regulation in insects is neurohormonally controlled (Nijhout 1994), and induced by external factors that anticipate the approach of adverse conditions. External stimuli include abiotic factors such as photoperiod and temperature regimes, and biotic factors such as nutrition, mating, and crowding (reviews in Leather et al. 1993 and Tauber et al. 1986). The precise hormonal mechanisms governing reproductive development in monarchs have been elucidated (Barker & Herman 1973; Herman 1975, 1985). Photoperiod and temperature have been shown to influence reproductive development in posteclosion monarchs (Barker & Herman 1976), but this study identified only optimal and inhibitory conditions.

Here we identify the environmental cues involved in diapause induction in eastern North American monarchs. We studied the natural incidence of male and female diapause in Minnesota and Wisconsin (USA) populations and conducted a series of controlled induction experiments, testing the effects of photoperiod, hostplant characteristics, and temperature on female reproductive diapause.

Methods

Assessing diapause

Summer reproductive female monarchs have pronounced ovarian development, with mature (yolked with a ridged chorion) oocytes in each ovariole 6 days after eclosion (Oberhauser & Hampton 1995), while those in reproductive diapause have small ovarioles without mature oocytes. We used an absence of mature oocytes in nine-day-old females to indicate diapause (Herman 1973), dissecting females under 6x magnification on a Wild dissecting microscope and examining the ovaries for mature oocytes.

Diapause males have much smaller reproductive organs than reproductively active males. Herman (1985) noted a sharp reduction of at least 50% in the mean ejaculatory duct mass during the diapause period (late August through October) in males collected from wild. We used the mean wet weight of the ejaculatory duct portion of the male reproductive complex to assess male diapause. We dissected adults under 12x magnification, in insect saline, cleared fat bodies and tracheae from the lower portion of the reproductive tract complex and then removed the ejaculatory duct. This portion of the tract is identified as the lowest section from the aedeagus to the tubular gland and is separated from the tubular gland by a narrowing region. Once removed and cleared of any remaining fat bodies, the ejaculatory duct was blotted on absorbent tissue and weighed to .01 mg on a Mettler balance.

Since age and mating history of animals collected from wild populations are unknown, we can not assess diapause in the same manner as laboratory reared animals. Mating behavior in males and oviposition in females, however, are clear indicators that these animals are not in diapause. Reproductive status of males collected from wild populations was assessed through observation of mating. We held male butterflies in a large, outdoor mating cage with laboratory stock females, maintaining a minimum 1:1 sex ratio to ensure sufficient females for mating. Males that successfully mated were considered reproductive and were subsequently released. We assessed the status of wild females both behaviorally and through dissections. Wild caught females were held in individual cages with fresh milkweed for two days. Females that oviposited were considered reproductive and were released. To allow for the possibility that non-ovipositing females were immature or not mated, we placed them in the mating cage for up to five days and once, mated, transferred them to oviposition cages. Non-mating females and females that did not oviposit within five days of mating were then dissected as described above.

Natural incidence

We collected weekly samples of adults in south central Minnesota and southwestern Wisconsin (USA) from mid-summer (July) through early fall (September), 1995, to assess the reproductive status of monarchs through the season. We held adults in outdoor cages on the University of Minnesota St.Paul campus, fed them a 25% honey solution daily, and observed their mating and oviposition behavior. We also reared weekly samples of 15–20 eggs (hatched on the same day) from females collected between mid-July and mid-August, with the exception of the initial cohort ($n = 9$) which was collected as eggs and first- or second-instar larvae from the wild on 19 July. We reared cohorts of larvae outdoors through to the adult stage, feeding them fresh milkweed (*Asclepias syriaca*) cuttings daily. We measured adult mass and winglength 24 hours after eclosion and dissected adults at age nine days, as described above.

Diapause induction experiments

We conducted a series of experiments in which we varied environmental conditions experienced by the larvae, testing the effects of photoperiod, hostplant characteristics, and temperature on the proportion of females in diapause. Values for each treatment variable were chosen to mimic natural environmental conditions present when diapause is occurring in wild populations. In each experiment, we kept monarchs in the experimental conditions from the day of hatching through to dissection in the adult stage. All animals were first or second generation offspring of adults captured in east-central Minnesota and west-central Wisconsin.

Photoperiod only

We measured the effect of photoperiod using three treatments: long daylength (16:8 L:D), short daylength (13:11 L:D), and decreasing daylength (starting with 15:9 L:D and decreasing by 3 minutes per day). Daylength in Minnesota (45ºN latitude) is 15:9 L:D on 23 July and decreases by 2 to 3 minutes per day in August (Watson et al. 1995). We chose these daylength treatments to represent early summer, when all monarchs are reproductive; mid-to late summer (late July–late August), when diapause individuals are developing; and early fall, the end of the breeding season for monarchs. This experiment was conducted from late January through early March 1995.

We equipped each treatment chamber with a standard florescent fixture with one 40W and one 30W bulb suspended 3 feet above a table top on which larva cages were kept. Photoperiods were set by programmable appliance timers. These chambers were three adjoining rooms (3 x 3 m) on one heating and ventilation system. Temperature was measured daily and did not vary significantly between chambers (mean = 23.2º, s.e. = 0.4ºC). Humidity was monitored weekly and pans of water set in the rooms to maintain 25% relative humidity.

At the start of the experiment, we transferred newly hatched larvae to potted, greenhouse-grown *A. currisavica* plants in screen cages (56 x 40 x 31 cm, with 25 larvae per cage). Two cages per treatment were placed in each chamber. Additional potted plants were provided as needed to maintain a constant food supply. The greenhouse in which milkweed was grown was maintained on a 14:10 L:D photoperiod. Plants were watered approximately every three days and fertilized weekly. Larvae pupated in the cages and one-day-old adults were weighed and their wings measured. We kept adults in glassine envelopes under the same conditions, feeding them a solution of 25% honey water *ad libitum* every other day, and dissecting nine-day-old females.

Photoperiod and hostplant

From mid-March through April, we examined the effects of daylength and hostplant in a 3x2 factorial design. Photoperiod treatments were modified from the previous experiment as follows: long daylength was 16:8 L:D, short daylength was shortened to 10:14 L:D, and decreasing daylength began with 14:10 L:D decreasing by 3 minutes per day. The short daylength setting was modified, given the lack of effect from the previous experiment. Treatment chambers, light fixtures, temperature, humidity and rearing cages were identical to the previous experiment.

Larvae in this experiment were reared on greenhouse *A. currisavica* plants; however, hostplant quality was varied to simulate differences between tender young plants of early season growth and old, senescing plants of late season growth. Young hostplants had approximately one-month leaf growth and old hostplants were 8–9-month-old flowering plants that had been cut back previously. Old plants were watered half as frequently. 33 to 40 larvae were reared per treatment. Newly-hatched larvae were transferred to potted plants and reared as described above.

Photoperiod, temperature and hostplant

This experiment was conducted in July/August 1995 and repeated in late August/September 1995. In both blocks, we reared animals in temperature and photoperiod controlled Percivel Model E-30B growth chambers. Three factors (photoperiod, temperature and hostplant quality) were examined in a 2x2x2 factorial design.

Long and decreasing daylength treatments were set as in the previous experiment, but the short daylength treatment was dropped, given no effect from the previous experiments and the limits of the experimental design. Temperature regimes included a constant (27ºC) and a fluctuating temperature (27ºC thermophase to 21ºC cyrophase). This is more conservative than the average amplitude of temperature variation in Minnesota at this time of year: high 27ºC / low 16ºC (Watson et al. 1995).

Milkweed (*A. syriaca*) is widely available in our region at this time of year. To simulate simultaneous young and old hostplant quality, we used a combination of wild and greenhouse-grown *A. syriaca*. In the first round of the experiment, since only new plant growth was available, we used cuttings from flowering greenhouse *A. syriaca* plants that were several months old for old hostplant treatments. Larvae in young hostplant treatments were supplied cuttings from new shoots of wild milkweed. In the second round of this experiment, later in the season, both old stalks of milkweed (with seed pods and tough, yellowing leaves) and new growth from plants that had been mowed (tender, unblemished, green leaves) were available. Cuttings from each of these categories were used for the old and young hostplant quality treatments, respectively. In both rounds, we used floral tubes to keep milkweed cuttings fresh and changed the milkweed daily. We reared larvae in plastic tubs (30 x 17 x 11 cm) with screened lids. Initial larval tub density was 15 larvae per tub. Larvae pupated in the tubs and were kept in the experimental treatments until dissection.

Statistical analyses

Since the female response variable is binomial (presence or absence of mature oocytes), we used logistic regression models in our analyses. To test the importance of treatment variables as predictors of diapause, we performed a stepwise analysis of deviance for each experiment. Continuous variables were analyzed using analysis of variance. We used probabilities of 0.05 to indicate statistical significance.

Results

Natural incidence of diapause

All wild-caught females collected and held through 23 August were reproductive (Table 1a). Oviposition behavior and presence of mature oocytes decreased after this date. Male reproductive behavior (mating) began to decline earlier, in mid-August, and ceased by end of August (Table 1b). Almost all reproductive behavior ceased in wild-caught adults in the last two weeks of collection, corresponding to the peak of migration in Minnesota. Adults that died within 2 days of capture were excluded from these results.

Table 1a Reproductive activity in female butterflies caught weekly in Minnesota and Wisconsin

Week evaluated	n	Number that laid eggs	Number with eggs	% Reproductive
7/19–7/26	5	3	2	100
7/27–8/2	4	3	1	100
8/3–8/9	2	2	0	100
8/10–8/16	3	3	0	100
8/17–8/23	1	0	1	100
8/24–8/30	3	1	1	66
8/31–9/6	16	4	1	31
9/7–9/12	5	0	0	0

Note: Logistic regression analysis of deviance using "Week evaluated" as the predictor for diapause in females is significant ($\chi^2 = 28.94$, df = 1, $p<0.001$).

Table 1b Reproductive activity in male butterflies caught weekly in Minnesota and Wisconsin

Week evaluated	n	Number that mated within 5 days	% Reproductive
7/19–7/26	8	8	100
7/27–8/2	2	2	100
8/3–8/9	5	5	100
8/10–8/16	4	4	100
8/17–8/23	5	3	60
8/24–8/30	8	2	25
8/31–9/6	24	0	0
9/7–9/12	10	0	0

Note: Logistic regression analysis of deviance using “Week evaluated” as the predictor for diapause in males is significant ($\chi^2 = 69.1$, df = 1, $p<0.001$).

In the weekly cohorts (Table 2), all females that emerged on or before 24 August developed mature oocytes, with the exception of one female in the first cohort. In the weeks of 31 August and 11 September, 46% and 100%, respectively, of the females were in reproductive diapause. Male reproductive tract development also changed through the season. Correcting for size by dividing ejaculatory duct mass by body mass at emergence, there was a significant relationship between reproductive development and date emerged. Ejaculatory ducts were significantly smaller in late season cohorts. There was no difference in adult mass between cohorts.

Table 2 Reproductive development in weekly cohorts of monarchs reared outdoors from eggs

Date eggs laid	Date adults emerged	n	*Females* % reprod.	Mean mass (g)	n	*Males* Mean ED/mass*	Mean mass (g)
–	8/13	7	86	.5322	2	.0413	.5227
7/16	8/19	8	100	.4676	8	.0348	.4850
7/28	8/24	11	100	.5019	9	.0272	.5015
8/3	8/31	13	54	.4851	9	.0214	.4875
8/12	9/11	7	0	.5167	8	.0108	.5459

* Ejaculatory duct mass divided by body mass “Date emerged” is a good predictor for diapause in females (logistic regression analysis of deviance, $\chi^2 = 21.72$, df = 1, $p<0.001$) and in males (linear regression, ED/mass = .04–.007 * Date emerged, $R^2 = 0.68$, $p<0.001$).

No difference in adult mass between cohorts (females: $F(4,40) = 2.17$, $p = 0.0893$ and males: ($F(4,36) = 2.37$, $p = 0.0706$).

Diapause induction

Photoperiod

Figure 1a shows the percentage of nine-day old females in diapause in each daylength treatment. Daylength, as the combination of the three design variables—long, short, and decreasing—is a good predictor of diapause in females ($\chi^2 = 19.28$, $df = 2$, $p = 0.0007$). In order to assess whether a particular daylength treatment is important, we examined the Wald statistic and log-odds ratio of each design variable (Table 3). There was a significant contrast between decreasing and other daylength treatments (significant contrasts are evident when the Wald statistic >2 and when log-odds ratio are different from one). A decreasing daylength is the best predictor of diapause, with odds of inducing diapause 8 times that of other photoperiod treatments. Daylength treatments did not affect adult mass ($F(2,54) = 2.24$, $p = 0.116$) nor average wing length ($F(2,60) = 0.02$, $p = 0.969$). Further, mass did not differ between reproductive and diapause females ($F(1,55) = 0.04$, $p = 0.839$).

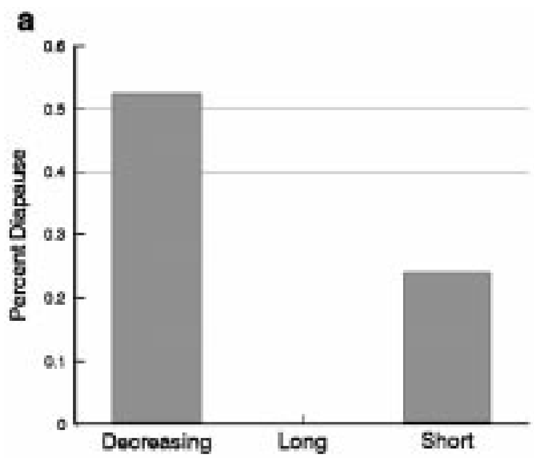
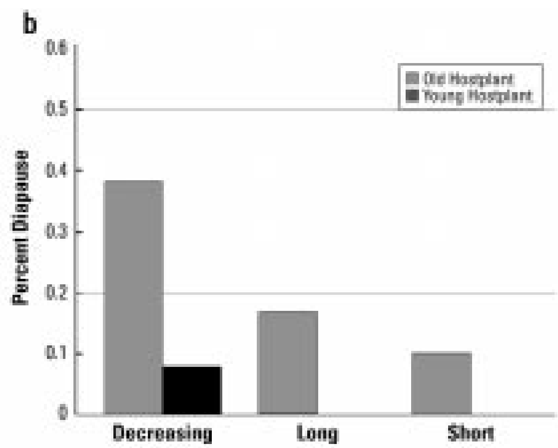


Figure 1. Percentage of diapause in females from three induction experiments: (a) photoperiod only, (b) photoperiod and hostplant quality, and (c) photoperiod, temperature and hostplant quality. Only significant treatments are shown.



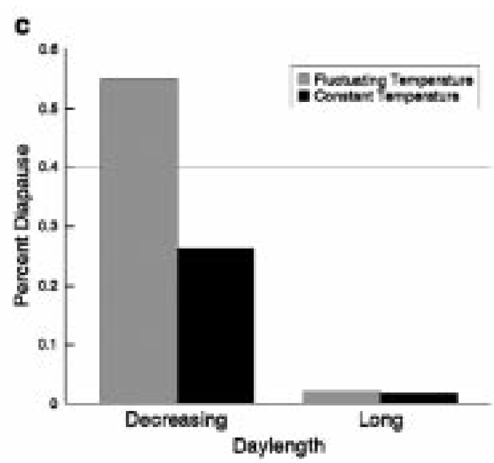


Table 3	Analysis of daylength design variables in predicting female diapause				
Design variable	**Wald statistic**	**p**	**95% C.I. lower limit**	**Log-odds ratio**	**95% C.I. upper limit**
Decreasing	3.25	0.0012	2.3	8.14	28.14
Long	0.57	0.5659	0	0	∞
Short	-0.2	0.8377	0.26	0.88	2.97

Photoperiod and hostplant

The greatest percentage of female diapause in this experiment occurred when butterflies were reared under decreasing daylength and fed old hostplants (Figure 1b). To assess the importance of each treatment variable, four models were tested in a stepwise analysis of deviance: null, a photoperiod effect, a hostplant quality effect, and a combination of both cues. The most parsimonious model includes only hostplant and decreasing daylength treatments (Table 4a). Adding an interactive term between hostplant and decreasing daylength does not significantly reduce model deviance. The odds of diapause for females reared on old hostplants, given a decreasing daylength, are 12 times the odds for those reared on young hostplants (Table 4b). The odds of diapause under a decreasing daylength treatment, given old hostplants, are 5 times the odds for other daylengths. Both factors contribute to the likelihood of diapause, but the lack of a significant interaction implies that their functions are additive.

Table 4a	Summary of binomial regression model for female diapause in photoperiod and hostplant induction experiment			
Predictor	**Coefficient**	**Std. error**	**Coef/SE**	***p***
Constant	-4.541	1.085	-4.18	0.000
Oldhost	2.506	1.063	2.36	0.0184
Decreasing	1.617	0.605	2.67	0.0075
Deviance	72.28			
d.f.	112			

Table 4b	Log-odds ratios for female diapause in photoperiod and hostplant induction experiment		
Predictor	**95% C.I. lower**	**Odds ratio**	**95% C.I. upper**
Oldhost	1.53	12.26	98.44
Decreasing	1.54	5.04	16.5

To rule out an effect of poor nutrition on reproductive development, we examined mean mass at emergence. There was a relationship between mass and hostplant, but females in the old hostplant treatment were significantly larger (Figure 2a); mean mass in old hostplant treatments of 0.5377 g compared to a mean mass in young hostplant treatments of 0.4725 g, ($F(1,113)=60.16$, $p<0.001$). The mass of females in diapause is not significantly different from reproductive females (Fig. 2b, $F(1,113)=2.86$, $p=0.0938$).

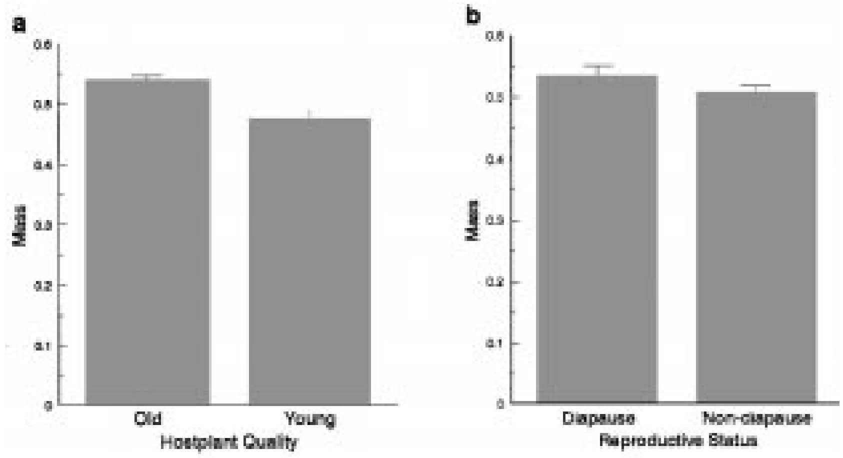


Figure 2. Mean mass at emergence for females in photoperiod and hostplant quality induction experiment: (a) mean mass for females reared on old (n=70) vs. young (n=45) hostplants, and (b) mean mass for diapause females (n=15) vs. reproductive females (n=100). Error bars represent standard error of the mean.

Photoperiod, hostplant, and temperature

The greatest percentage of female diapause occurred under decreasing daylength and fluctuating temperature conditions (Figure 1c). Stepwise analysis of deviance of all predictor variables revealed that neither hostplant nor block had a significant effect in this experiment. There was no effect of an interaction between daylength and temperature, indicating that the two cues work in an additive, not synergistic, manner. A summary of the resulting binomial regression model and the log-odds ratios are given in Table 5. The odds of diapause under decreasing daylength conditions, given the fluctuating temperature regime, are 38 times that under long daylengths. Odds of diapause under the fluctuating temperatures, given a decreasing daylength, are 3 times that of the constant temperature regime.

Table 5a Summary of binomial regression model for female diapause in photoperiod, temperature and hostplant induction experiment

Predictor	Coefficient	Std. error	Coef/SE	*p*
Constant	-4.659	0.756	-6.16	<0.0001
Daylength	3.651	0.736	4.96	<0.0001
Temperature	1.170	0.406	2.88	0.0040
Deviance	150.68			
d.f.	214			

Table 5b Log-odds ratios for female diapause in photoperiod, temperature and hostplant induction experiment

Predictor	95% C.I. lower	Odds ratio	95% C.I. upper
Decreasing daylength	9.10	38.5	162.98
Fluctuating temperature	1.45	3.2	7.15

Discussion

Assessing the timing and progression of diapause

There is a pronounced change in reproductive behavior and development in male and female monarchs captured in late August and early September in the north central United States. There is a similar change in reproductive status of individuals reared in outdoor conditions. Since the actual age and reproductive history of adults captured from the wild is unknown and these animals experienced different conditions during development, direct comparison of results from these two data sets is not feasible. Herman (1985) reported a similar change in measures of wild male and female reproductive tracts.

Half of the females reared outdoors that emerged during the last week of August and all females of the final cohort (emerged 11 September) were in diapause (without mature oocytes). This change is similar to that of wild females: by the last week in August, one third of wild females had ceased oviposition, this percentage doubled in the next week, and by the second week of September all were in diapause. The shift to diapause in females begins in the last half of August.

The onset of male diapause appears to be more gradual. In the weekly cohort males, reproductive tract mass decreased steadily over five weeks. Herman (1985) noted that there was a reduction in the mean ejaculatory duct mass by approximately 50% between summer and fall in males collected from wild populations. Our experiment showed similar results. By the last week of August, mean ejaculatory duct mass corrected for body mass was roughly half that of the earliest cohort, indicating diapause at this time.

Environmental cues

Decreasing daylength

In all three induction experiments, there was a significant effect of a decreasing daylength on diapause induction (Figure 1). Constant short and long daylengths resulted in few or no females in diapause, as did long daylength. While it is possible that the salient feature of our daylength treatments is the absolute number of hours of photophase and scotophase experienced during the insect's sensitive period, rather than the rate of change over time, we think it unlikely. If monarchs were responding to an absolute critical daylength, the short daylength treatment should result in at least as great a percentage diapause as decreasing daylengths, not less.

While early diapause induction studies focused on the importance of a critical constant photoperiod, there is increasing evidence of diapause induction from stimuli involving changes in photoperiod experienced during an insect's sensitive stage (Solbreck 1979; reviews in Tauber et al. 1986; Nylin 1989; Han and Gatehouse 1991). It is likely that a decreasing photoperiod may have a more pronounced effect on insects in higher latitudes where the change is more perceptible (Taylor & Spalding 1986; Han & Gatehouse 1991; Gatehouse & Zhang 1995) and also in insects that migrate over long distances where offspring of different generations are exposed to different photoperiods (Solbreck 1979). Our results support Solbreck's suggestion that an insect's response to decreasing daylength, as opposed to a critical photoperiod, is an adaptation that enables synchronization with habitat at different latitudes, particularly in insects with great dispersal power. The salient cue for these animals is the change in daylength experienced at different latitudes.

Temperature

Diapause induction in monarchs includes a thermoperiodic (daily temperature cycle) cue. Diapause was twice as likely to occur in females reared under a conservative fluctuating temperature treatment where night temperatures were lower than day. Although not as reliable a cue as photoperiod, temperature is a seasonably-variable abiotic stimulus. Most investigations of temperature and diapause induction have focused on the modulating effect of a particular critical temperature on photoperiod cues, with few studies focusing on the primary effect of temperature, in particular thermoperiod, on diapause induction (Beck 1982; van Houten et al. 1987). Response to a fluctuating temperature regime may be a function of reaching a threshold temperature in the cryophase, a function of the duration of each phase of the cycle, or a function of the differences between phases (Beck 1983). While the precise mode of action is uncertain, our results suggest that temperature intensifies the effect of photoperiod on diapause induction and that monarchs respond to some aspect of thermoperiod with amplitude as little as 6ºC. Thermophase/cyrophase amplitudes experienced in late summer in Minnesota are closer to 10ºC (Watson et al. 1995). Higher latitude climates will have greater differences between day and night temperatures and it seems likely that this amplitude can serve as a fairly predictable cue.

Hostplant characteristics

Response to manipulations of hostplant characteristics in our experiments was mixed. In the photoperiod and hostplant experiment, in which we used greenhouse-grown *A. currisavica*, there was a distinct effect of old hostplants on diapause induction. In the final experiment, in which we used wild and greenhouse-grown *A. syriaca*, hostplant characteristics had no effect. This could be due to inadequate control of plant factors indicating hostplant characteristics. Greenhouse plants were more consistently manipulated, whereas controlling for changes in naturally-growing milkweed was difficult. It is possible too that a hostplant effect is expressed differently in *A. currisavica* and *A. syriaca*. Koveos and Tzanakakis (1989) and Hunter and McNeil (1997) both saw differential diapause response in animals reared on different species of hostplants.

The mechanisms by which a hostplant cue may induce diapause are largely uninvestigated, although, like temperature, they probably operate by modulating the effects of another cue. Any cue from the hostplant must be a consistent plant response to late season growing conditions (e.g.: withdrawal of protein from leaf tissue, toughening of leaves, presence of flower and seed pod). Hunter and McNeil (1997) propose a nutritional mechanism for diapause induction in the polyphagous tortricid moth, *Choristoneura rosaceana*, suggesting that hostplants with different protein content affect the insects' development rate in relation to a photoperiod-sensitive stage for diapause induction. In a mite (*Petrobia harti*), Koveos and Tzanakakis (1989) found that higher percentages of females laid diapause eggs when they were fed leaves from flowering plants vs. non-flowering plants, under diapause-inducing photoperiods. In both investigations, the insects responded to a plant-provided cue. Since the limits imposed by hostplant rearing forced us to compare greenhouse to wild *A. syriaca*, the importance of hostplant quality as a diapause cue is unclear at this point. Our results with *A. currasavica* suggest that there is a function, but we do not know the mechanism by which this may act to help induce diapause.

Combination of cues

When we tested the effects of multiple environmental cues on diapause induction, there was a significant increase in the percentage of diapause with the addition of a second cue. Hostplant characteristics in the second experiment and temperature in the last experiment both influenced the proportion of females that entered diapause. Rearing larvae on old hostplants significantly increased the percentage of diapause in decreasing daylength treatments and rearing larvae in a fluctuating temperature regime also served to significantly increase the percentage of diapause in decreasing daylength treatments. The lack of a significant interaction term in the regression models suggests that these cues act additively, not synergistically. Using more than one cue to assess the current suitability of habitat is a safer strategy for organisms in unpredictable environments. That some monarchs still diapause with only one cue suggests within population variation in response to environmental stimuli.

Variation in diapause response

Our results show that there is a gradual shift to diapause in response to environmental conditions and these confirm earlier reports of seasonal ovarian development in monarchs (Herman 1985). Rather than observing an abrupt shift to diapause under a particular suite of conditions, this gradual change in response to environmental cues suggests within population variation, where some monarchs diapause and others remain reproductive. This was true in adults collected from the wild as well as in monarchs reared outdoors and in induction experiments under decreasing daylengths.

Variation in diapause response is to be expected, particularly along geographical gradients (Taylor & Spalding 1986); however, variation typically declines in higher latitudes (Vinogradova 1986). In unpredictable environments, selection will favor individuals best able to exploit habitat while it is available. Individuals may do so by responding to secondary cues (e.g.: temperature and hostplant quality, indicating the extension of favorable conditions) and producing an extra generation. While our results represent the response of northern latitude monarchs, there is considerable seasonal habitat variability from year to year, favoring variable responses by the monarchs. Further, any strong latitudinal response in monarchs may be lost each year, given panmictic mating in the overwintering colonies in central Mexico.

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The use of bursa copulatrix dissection and abdominal palpation to assess female monarch butterfly mating status

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Abstract

Female monarchs mate multiply, store sperm, incorporate spermatophore-derived nutrients into their somatic tissues and eggs, show last male mating advantage in egg fertilization, and mate *en masse* before leaving overwintering sites. Knowledge of when females receive spermatophores is therefore important to understand; 1) monarch mating strategies, 2) selective pressures on migration-diapause life history strategies, and 3) implications of human threats to monarch migration. Here I assess the usefulness of bursa copulatrix dissection and abdominal palpation to determine female mating status at a Mexico overwintering site. Bursa copulatrix dissection provides a means to quantify polyandry and to differentiate matings that occurred during the mass mating period from those that occurred previously. However, this method is somewhat cumbersome and requires killing the female. The overall level of polyandry can also be determined quickly and without harm by counting the number of spermatophore stems (collums) removed from the copulatory orifice (ostium bursae). However, this method cannot differentiate among matings that occurred during different parts of the migratory cycle. Abdominal palpation can be used to describe the timing and proportion of females mating during the mass mating event and to indicate changes in mating status among sub-colonies, different activities, and years. Palpation is simple, does not require equipment, and does not injure the female.

Introduction

The monarch butterfly mates under distinctly different ecological conditions during the summer breeding and the overwintering mating periods. Summer breeding is characterized by overlapping generations that occur in dispersed populations associated with larval food plant distribution. Mating and egg-laying overlap spatially and temporally. In contrast, the overwintering mating period follows a long-distance southward migration and reproductive diapause, occurs under extremely dense population levels, is restricted to a few weeks just before the northward mass exodus, and is separated in space and time from larval food sources (Brower 1985; Wells & Wells 1992). Females leaving the overwintering areas are almost exclusively responsible for the initial re-population of summer breeding sites in the United States and Canada (Malcolm et al. 1993; Brower 1995).

Females incorporate spermatophore-derived nutrients into their somatic tissues and eggs (Boggs & Gilbert 1979; Wells et al. 1993), and polyandry is common (Pliske 1973; Hill et al. 1976; Suzuki & Zalucki 1986; Oberhauser 1989; Oberhauser & Frey this volume). Under laboratory conditions there is strong, but incomplete, last male mating advantage in egg fertilization (Oberhauser, pers. comm.). Autumn migratory females are reported to be in reproductive diapause and unmated (see Herman 1985; Goehring & Oberhauser this volume). However, females have been observed mating before leaving summer breeding grounds (Lessman & Herman 1983), during the autumn migration (Williams et al. 1942; pers. obs.), and early-on in the overwintering period at Mexico and California overwintering sites (Downes, in Williams et al. 1942; Hill et al. 1976; Tuskes & Brower 1978; Brower et al. 1977; Leong et al. 1995; Calvert pers. comm.; Alonso-M. pers. comm.). Furthermore, females arriving at California overwintering sites are occasionally mated (Downes, in Williams et al. 1942; Tuskes & Brower 1978; Leong et al. 1995), and non-virgin females predominate at Australian overwintering sites throughout the overwintering period (James 1984; James 1993). A sub-set of overwintering females mate or remate at overwintering sites. Mating may also occur during the remigration and is known to occur when females reach oviposition sites.

Knowledge of when female monarchs receive spermatophores is important to understand: 1) both male and female mating strategies, 2) selective pressures that shape and maintain the migration-diapause life history strategy, and 3) implications of human threats to monarchs. In this paper, I assess the usefulness of bursa copulatrix dissection and abdominal palpation to determine female mating status at a Mexico overwintering site. Specifically, I: 1) describe bursa dissection methods, 2) refine these methods to better detect the presence of very old spermatophores, and 3) compare mating status assessments based on dissection with those based on two non-invasive techniques: spermatophore stem (collum) counts and abdominal palpation. Consecutive daily abdominal palpations of just-mated females were used to determine how long recently obtained spermatophores are detected as such through abdominal palpation. This increased my ability to differentiate between females that had mated during the mass mating event from those that had mated before that time using abdominal palpation.

Together these methods can be used to: 1) determine the frequency of mating and the degree of multiple mating at Mexico overwintering sites, and 2) differentiate between matings that occurred during the early spring mass mating period from those that occurred previously; late in the summer, during the autumn migration, or early on in colony formation. This information is critical to test ecological and evolutionary hypotheses of monarch reproductive biology. Because reproductive biology is a key factor in conservation biology, these methods will also help to delineate how anthropogenic changes to monarch habitats influence their population dynamics.

Methods

Original bursa copulatrix dissection method

I dissected 669 females collected between 15 January and 25 March 1985 from the Sierra Chincua overwintering site in Michocán, MX. Approximately equal numbers of females were sub-sampled from combined daily collections from the following activity categories: clustered, flying, nectaring, and drinking.

Females were killed by cutting the head from the body, and then stored on ice at the overwintering site until dissected within three days under a 10–30X binocular dissecting microscope. At the time of dissection , the abdomen was cut from the thorax. The abdominal exoskeleton was then split longitudinally by sliding dissecting scissors just under the exoskeleton and cutting from anterior to posterior. With the exoskeleton pinned open on a dry paraffin surface, the bursa copulatrix was removed from the abdomen by cutting the ductus bursa at the junction with the exoskeleton wall. The wall of the bursa was then peeled open and the bursa contents exposed. A diagrammatic sketch of the female monarch reproductive organs is provided in Urquhart (1960, p. 243). Terminology used in this paper also comes from Drummond (1984).

During the dissection, I: 1) sketched a picture of the contents of the bursa, 2) recorded the color, shape, size, and viscosity of the contents, 3) noted the presence or absence of spermatophore wall pieces and the number of chitinized spermatophore necks, and 4) weighed intact spermatophores to the nearest 1 mg, using a model 1205 MP Sartorius balance. In order to obtain wet weights of intact spermatophores, I dissected the bursa dry (without adding water). I practiced these methods before beginning the sample dissections in order to increase my accuracy.

After dissecting all females, I used my sketches of the bursae contents to classify spermatophores as fresh, semi-fresh or old (disintegrated). Fresh spermatophores were relatively large, had turgid walls with full contents and the skin entirely intact. Old spermatophores were relatively small, deflated, and their walls were frayed or broken into pieces. I used either the chitinized neck (collum) or torn spermatophore wall pieces to confirm the presence of a completely disintegrated spermatophore. Semi-fresh spermatophores were intermediate between fresh and old spermatophores in size, turgidity and deterioration of the walls. Figure 1 shows representative examples of fresh, semi-fresh and old spermatophores, and a chitinized spermatophore neck.

Because fresh and semi-fresh spermatophores were distinct entities, the number present in the bursa copulatrix could be determined with certainty. I estimated the total number of old matings by the number of spermatophore necks found, since such spermatophores were physically broken into many pieces. I assumed that each mating resulted in a single spermatophore neck and that the chitinized neck did not disintegrate over time (see references in Drummond 1984 for support of these assumptions).

These spermatophore classifications were used to differentiate matings assumed to have occurred during the overwintering spring mass mating period (fresh and semi-fresh) from those assumed to have occurred previously (old), during late summer, during autumn migration, or during overwintering colony formation. Dissections of females that were collected *in copula* (unpubl. data), changes in spermatophore mass as detected by palpation (see below), and dissections of spring remigrants and summer breeders support these categorizations (see also Svärd & Wiklund 1988; Oberhauser 1992).

I could not directly test the accuracy of mating status estimates using the original dissection method because the true number of times overwintering females had mated could not be definitively determined. However, the spermatophore necks were likely sometimes overlooked, due to their tiny size (Figure 1) and because the bursa contents were sometimes very dried out and sometimes contained countless shredded spermatophore wall pieces of similar size to the neck. I therefore revised the original dissection method to include serial water washes and sonication of the bursa contents, in order to better detect the tiny spermatophore necks. Only dry weights of individual spermatophores can be obtained using the revised method, due to the addition of water during dissection.

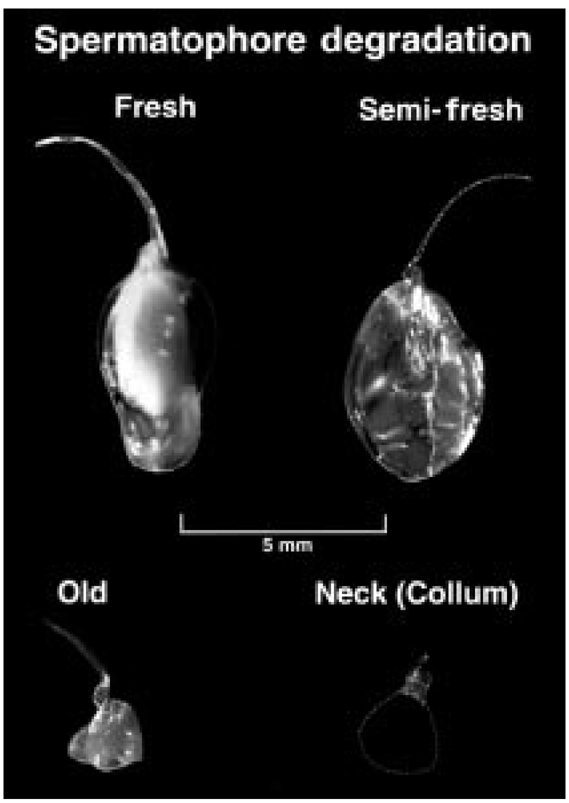

Figure 1. Representative examples of fresh, semi-fresh, and old spermatophores and a chitinized spermatophore neck from dissected *Danaus plexippus* females. The three classifications were used to differentiate between matings assumed to have occurred during the mass mating period (fresh and semi-fresh) from those assumed to have occurred previous to the mating period (old + chitinized necks), either in the previous late summer, during the autumn migration, or early-on in overwintering colony formation. This figure was created on Adobe Photoshop by importing four separate photographic images. Dotted lines were added to illustrate parts of the spermatophores that had either broken off (Semi-fresh: the stem) or completely degraded (Neck: the entire spermatophore except for the neck). Because fresh spermatophores were distinct entities, the number of fresh matings could be determined with certainty. Each spermatophore has a single chitinized neck and stem that remain after the rest of the spermatophore has degraded. These structures could therefore be used to detect the presence of completely deteriorated spermatophores and to estimate the number of matings when spermatophores were broken into indistinguishable pieces. Spermatophore necks extend from the bursa copulatrix opening and therefore can be used to determine the number of spermatophores without killing the female.

Revised dissection methods

The original dissection methods described above were altered in the following ways. First, before dissection, I inspected the females under a 10–30X dissecting microscope for spermatophore stems (thin chitinized extensions of the spermatophore neck; see Figure 1) that protrude from the ostium bursae, the exterior opening of the bursa copulatrix. The number of spermatophore stems, which remain in the ductus bursae after spermatophore deterioration, indicates the numbers of matings. Stems were removed from the ostium bursae using forceps, placed on a watch glass, flooded with distilled water, gently teased apart, and counted under the microscope. Second, I removed the bursa from the abdomen, opened it, and placed its contents on a watch glass. In order to minimize a possible bias in counts of spermatophore necks due to knowledge of the number of stems, I randomized the watch glasses in batches of five to ten before inspecting the bursa contents. I flooded the watch glass with distilled water and removed and counted intact spermatophores and spermatophore necks. Third, I washed the remaining bursa contents into a 9 ml glass tube and sonicated it in a Bransonic 12 sonicator for approximately five minutes. The sonicated contents were washed into a second watch glass and again inspected under the microscope. Spermatophore necks and wall pieces were removed upon positive identification. The remaining contents were washed with serial rinses until they were clear enough for positive identification of the remaining necks. Sonication and serial rinses greatly facilitated the ease of detection of spermatophore wall pieces and necks within the bursa contents.

Possible sources of error in estimates of female mating status

Two potential sources of error in estimates of female mating status based on bursa dissection were identified. Although the problem of overlooking spermatophore necks was lessened using the revised dissection methods, necks may be lost during transfer from the bursa to the watch glass or during transfers to and from the sonication tube. Overlooking or losing spermatophore necks would lead to: 1) an underestimate of the number of matings, and 2) an inability to definitively differentiate between virgins and non-virgins when bursa contents do not contain identifiable wall pieces.

The second problem occurred in a subset of females designated as virgins using the original dissection method. Females were classified as virgins based on the absence of detected spermatophore necks or spermatophore walls pieces. Most of these females had empty or fluid-filled bursa characteristic of known virgins (see below), but a subset contained a waxy material indistinguishable from that found inside spermatophores. If females cannot produce this material in the absence of mating, this subset of females classified as virgins (which made up 33% of all of the original 669 dissections) would be classified incorrectly. The estimated proportion of virgins would then be vastly overestimated, while the proportion of females with old spermatophores would be vastly underestimated.

Comparison of the number of spermatophore necks and stems

I made an indirect assessment of the accuracy of detecting spermatophore necks by comparing the number counted inside the bursa with the number of stems extending from the copulatory opening (before dissection) from the same female. For this test I dissected 78 females from three samples collected at the Sierra Chincua overwintering site in Michoacán, MX: 1) 24 January 1985, n = 25; 2) 17 January 1986, n = 22; and 3) March 1997, n = 31.

Since each spermatophore has a single neck from which extends a single stem (Figure 1), their numbers should agree. Because spermatophore stems are pulled directly from the copulatory opening before dissection and because they extend from a single opening, they should be less susceptible to being lost or overlooked than spermatophore necks. Consistently fewer counts of spermatophore necks versus stems taken from the same female would indicate that spermatophore necks are readily lost or overlooked. If so, polyandry estimates based on counts of the number of necks observed would underestimate mating frequency. Consistently fewer counts of spermatophore stems versus necks would indicate that the thinner, less heavily chitinized stems are more likely to disintegrate or fall out of the copulatory opening. This later finding would suggest that spermatophore necks are not readily lost or overlooked during dissection and that dissection is necessary to estimate the degree of polyandry. Agreement in the number of stems and necks would confirm their permanence and would validate using either to estimate the degree of polyandry in monarchs.

Does waxy material occur in known virgins?

In order to determine whether virgins can contain the ambiguous waxy material, I dissected known virgins kept under simulated overwintering conditions and inspected their bursae for the presence of the waxy material. If this material exists in known virgins, it supports the original designation of females with waxy material but without spermatophore necks or spermatophore wall pieces as true virgins. I dissected 37 laboratory-reared virgin females provided by Karen Oberhauser and Sonia Altizer from the University of Minnesota

(USA). These females emerged in Minnesota between 12 and 15 July 1997. Within a few days after emergence, the adults were shipped on ice to Tallahassee, Florida (USA) via overnight mail. In order to mimic overwintering conditions and extend their life span, I stored the females individually inside glassine envelopes in a conventional refrigerator until either they died (n = 23) or were killed for dissection on 31 October (n = 14). They were fed approximately once per week, using 30% sucrose dissolved in tap water. Females were moved from the refrigerator to the freezer within a few days of their death. Those remaining alive on 31 October were killed by freezing. All females were dissected dry, using the original dissection protocol in order to better compare the results with females dissected using the original dry dissection methods.

Female abdominal palpations

Males transfer sperm and other materials in a large balloon-like spermatophore to the female bursa during mating. By gently applying pressure between the thumb and index finger while feeling along the abdomen from anterior to posterior the hardened spermatophore mass can be detected (Tuskes and Brower 1978). I categorized females as virgin, freshly mated, or with old spermatophores based on the relative size and hardness of the spermatophore detected by palpation. Abdominal palpation is somewhat subjective and is expected to be better able to detect large, hardened, fresh spermatophores than small, deteriorated, old spermatophores. I therefore assessed the accuracy of determining mating status by palpation for females with fresh and semi-fresh spermatophores separately from those with old spermatophores. The assumed true mating status was determined by bursa dissection. Palpation accuracy was noted as the percentage agreement between palpation and dissection mating status designations for the same female. Before these females were dissected, I categorized each female as: 1) fresh or semi-fresh (assumed to have mated recently), 2) old (assumed to have mated before the spring mating period), or 3) virgin, based on abdominal palpation.

I tested the accuracy of abdominal palpation in detecting fresh and semi-fresh spermatophores in a subset of the 669 overwintering females that were dissected using the original dissection method. This subset (n = 62) was those females that were categorized as fresh or semi-freshly mated based on bursa dissection. I assessed the accuracy of abdominal palpation in distinguishing females with old spermatophores from virgins in a sub-set of females used to compare the number of spermatophore stem and neck counts (see above). They were collected in March 1997 from the Sierra Chincua, Michoacán, MX overwintering site (n = 32). I used only females that were dissected with the revised dissection method because sonication and serial water washes improved my ability to detect old spermatophores during dissection. Females that had been stored for a long period in the freezer were deleted from this analysis.

According to Oberhauser (1992), under summer conditions, just-transferred spermatophore contents shrink at a rate of approximately 3.3 mg/day for the first seven days, after which their weight stabilizes at approximately 5 mg for at least 20 days. Because this potential shrinkage could influence detection and categorization of fresh spermatophores by palpation, I estimated how long recently mated overwintering females retained spermatophore masses large enough to be subjectively palpated as recently mated. I collected 22 females from *in copula* pairs from the Sierra Chincua, Michoacán, MX overwintering site in 1988. The following day, after the male and female separated, each female was palpated and then placed in a mesh cage in the shade. I misted the cage daily with water but did not provide females with a food source. I again palpated each female at approximately 24 h intervals for two weeks and noted the date when my subjective assessment, based on size and hardness of the spermatophore, changed from the fresh to the old category. This experiment had to be ended after 14 days and before all mating status assessments changed from fresh to old.

Results

Comparison of the number of spermatophore necks and stems

Using the revised dissection methods, the number of spermatophore stems did not match the number of spermatophore necks in two of 78 cases (3%). Of these two discrepancies, in one case I found more stems and in one case I found more necks. In a third case, a stem was observed from inside the body cavity but could not be seen from the ostium bursae. No neck was found in this female. Apparently, stems can rarely bend back on themselves in such a way that the free end does not stick out of the copulatory opening. These stems are visible only after opening the body cavity of the female during dissection. Like spermatophore necks, spermatophore stems apparently do not disintegrate during the life of the female. Polyandry level estimates based on stem counts taken from the copulatory opening without dissection are about equal in accuracy as those based on neck counts from bursa dissections.

Five (6%) of the 78 females dissected using the revised methods contained spermatophore contents that were intact enough for positive identification but in which no spermatophore stems, necks or wall pieces were observed. In my experience of over 2,000 bursa dissections I have never seen evidence of deterioration of a spermatophore neck. I therefore assume that either: 1) both the neck and stem can be present but overlooked in a small percentage of females with very old spermatophores, or 2) spermatophores can be secreted into the bursa without the formation of a chitinized neck. In either case, these results suggest that approximately 6% of females classified as virgins based solely on evidence of spermatophore stems and/or necks may have mated. In agreement with this level of error in the number of counted necks, in 225 bursa copulatrix dissections of spring remigrating monarchs collected in 1986 (unpubl. data), the percentage of females found with fewer spermatophore necks than stems protruding from the ostium bursae was 16 (7%). The error in differentiating virgins from non-virgins can be reduced by inspection of the bursa for spermatophore wall pieces. However, the number of matings must rely on counts of stems and necks when spermatophores are no longer intact units.

Does waxy material occur in known virgins?

Of the 37 laboratory-reared virgins, 11 (30%) had waxy material inside the bursa and 26 (70%) had either empty or fluid-filled bursae. No spermatophore-like material, stems or necks were found in these known virgins. These findings support my designation of females with no other evidence of spermatophore wall pieces, spermatophore necks, or spermatophore stems as virgins. Of the original 451 females classified as virgins in the overwintering sample of 1985, 221 (49%) had waxy material but no other evidence of mating. The presence of waxy material in laboratory-reared known virgins supports my designation of these females as virgins. However, the true percentage of virgins in the original sample is likely to be slightly lower because these females were dissected before the revised method was developed; I did not count spermatophore stems and I likely overlooked some necks in females with very degraded spermatophores.

Palpation versus bursa copulatrix dissection

Of the 62 females that had fresh or semi-fresh spermatophore based on dissection, 95% were classified correctly using abdominal palpation. All errors were false negatives; females palpated as having old spermatophores when the true mating status was fresh or semi-freshly mated based on dissection assessments. My dissection notes and drawings of the spermatophores suggest that these false negatives were due in part to the small size of some intact spermatophores and in part to my inconsistency in differentiating between semi-fresh and old spermatophores in the early dissections. Of the 62 females that had fresh or semi-fresh spermatophores, three also had old spermatophores and two had more than one fresh and/or semi-fresh spermatophore. The potential error due to confusing multiply mated and freshly mated females (false positives) was apparently not a significant source of error in this study but is expected to cause confusion when multiple mating is common, mating intervals are short, and the degree of polyandry is high.

Not surprisingly, mating assessment by abdominal palpation was less accurate in detecting old spermatophores than fresh or semi-fresh spermatophores. In matched samples, 85% ($n = 32$) of abdominal palpation results were consistent with dissection results in detecting the presence of deteriorated spermatophores. I classified females with an old spermatophore as a virgin (false negative) 4 times (13%), while I classified virgins as mated (false positive) 1 time (3%). Because there is a much higher percentage of virgins than females with old spermatophores as determined by dissection (Van Hook 1996), mistaking 13% of females with very old spermatophores as virgins by palpation is expected to add negligible error to estimates of mating frequency. The high proportion of virgins at the Mexico overwintering site (Van Hook 1996) suggests that palpations will only slightly underestimate (by approximately 3%) the true proportion of virgins.

Palpation accuracy and spermatophore degradation through time

All 22 of the just-mated females were classified as freshly mated for seven or more consecutive days. Five (22%) remained in the freshly mated category on day 14 when the experiment had to be terminated. Excluding these five females, the median number of days that females remained in the freshly mated category was 11 and the mode was 10. Because the five females that remained the longest number of days in the freshly mated category were excluded from the calculation of the median and mode, these estimates are likely to be very conservative. However, actively flying, nectaring, or courted females may utilize spermatophores much more quickly (see Oberhauser 1992).

Several lines of evidence suggest that abdominal palpation can differentiate between matings that occurred during the overwintering early-spring mass mating period from those that occurred during the previous summer or during the autumn migration. These include: 1) the constancy of spermatophore size over time (see above), 2) the consistency of mating status estimates by palpation compared with dissection (see above), 3) an absence of freshly mated females (as determined by bursa copulatrix dissection) before mass mating was observed in the field (Van Hook 1996), and 4) the exponential nature of the increase in the frequency of female mating during the mass mating event (Van Hook 1993, 1996).

Discussion

The frequency and degree of polyandry incurred in the late summer, during the southward migration, and during overwintering colony formation is expected to influence mating strategies during and after the spring mass mating event, and all pre-overwintering dispersal matings potentially influence remigration population demographics. The significance of such matings depends on female remating interval, sperm competition, the fate of male-derived nutrients transferred in spermatophores, and the length of time that sperm remains functional within the female reproductive tract. Long-term storage of viable sperm has not been studied in monarchs but occurs in other lepidopterans (Davey 1965, Parker 1970, Wiggleworth 1972, in Drummond 1984).

In this paper I develop bursa copulatrix dissection and abdominal palpation methods in order to determine the degree of polyandry, to differentiate between matings that occur during the mass mating period from those that occurred previously, and to distinguish between virgin and non-virgin females. This information is critical to test hypotheses of monarch mating ecology and can help to delineate how anthropogenic changes to monarch habitats influence their population dynamics. Table 1 summarizes the costs and benefits of the various mating status assessment methods.

Table 1 Comparison of female monarch mating status assessment methods

	Palpation	Stem Inspection	Dissection
Degree of Polyandry	No	Yes	Yes
Virgin vs. Old Matings	No	Yes	Yes
Overwintering Population Mating Frequency	Yes	No	Yes
Differentiate Overwintering and Autumn Matings	Yes	No	Yes
Necessary to Kill Female	No	No	Yes
Equipment Needed	No	Yes	Yes
Speed of Assessment	Fast	Fast	Slow

Using the mating assessment methods described in this paper to study mating ecology of Mexico overwintering monarchs, I have been able to show that: 1) females mate during the southward migration and/or early on in the overwintering period, 2) the mass mating event is restricted to the last few weeks of overwintering, increases in an exponential fashion, and most matings occur just before or just after the main exodus from the overwintering site, 3) female utilization of spermatophore contents may increase as the mating event begins, 4) many females leave the overwintering site without having mated during the mass mating event, but not necessarily as virgins, and 5) multiple mating during the mass mating period is rare, but already mated females may mate again during the mass mating period (Van Hook 1996).

Bursa copulatrix dissections

The revised dissection methods, that include the addition of serial water washes and sonication of the bursa contents during dissection, improved the detection of the tiny spermatophore necks. Comparisons of the number of spermatophore necks and stems suggest that my dissection method provides a good, but imperfect, separation of virgins from females with old spermatophores. Fluids and waxy material similar to that found inside spermatophores may be present in virgin females and therefore do not, in themselves, indicate mating. The presence of necks, stems or spermatophore skin pieces is necessary to classify a female as definitely mated. Because, rarely, both stems and necks may be overlooked, the bursa contents should also be inspected for spermatophore wall pieces in order to differentiate virgins from mated females.

The degree of polyandry can be assessed by either the number of spermatophore stems extending from the copulatory opening or the number of spermatophore necks in the bursa copulatrix. Spermatophore stem counts should be preferred when the female does not need to be killed to determine the relative timing of multiple matings. Both methods slightly underestimate the true number of matings due to the loss of or overlooking the tiny structures. Therefore, when dissection is necessary, both stems and necks should be compared for the best estimate of the number of matings.

Dissection methods are more accurate than palpation in determining the relative time of when females receive multiple spermatophores, especially when old spermatophores are very degraded. However, dissection requires equipment, is time consuming, and necessitates killing the female. Differentiation of matings that occurred during the mass mating event from those that occur much earlier in the overwintering season, late in the summer, or during the autumn migration are based on spermatophore size and degree of degradation.

Previous studies have generally lumped together samples across the overwintering period to estimate the frequency of mating and degree of polyandry then ascribed to the relatively brief mass mating event. Using bursa copulatrix dissection methods described in this paper, I found that 31% of all females overwintering at the Sierra Chincua, MX site had mated long before the mass mating event began in mid-February (Van Hook 1996). That study and others (e.g., Brower et al. 1977; Brower 1985; Leong et al. 1995) suggest that such lumping can overestimate the importance of mating during the mass mating event.

Abdominal palpation

Female abdominal palpation is simple, rapid, does not require any equipment, and does not harm the female. It may be useful to describe the timing and intensity of the Mexico overwintering mass mating event and to indicate differences in mating status among sub-colonies, among different activities, and among years.

Palpation provides an accurate (95%) method for detecting fresh spermatophores. Palpation is less accurate (84% accurate) in detecting extremely deteriorated spermatophores. The results are somewhat subjective and accuracy will likely improve with practice. The occurrence of fresh spermatophores is likely to be slightly underestimated due to the small size of some fresh spermatophores and to deterioration of the spermatophore through time. Errors in detection of old spermatophores arise from the inability to differentiate: 1) between old spermatophores and recent matings in which small spermatophores were transferred, 2) between multiple old spermatophores and single fresh spermatophores, and 3) between very old matings and virgins.

The low incidence of multiple mating (Van Hook 1993) and slow rate of spermatophore degradation found in Mexico overwintering females (this study) suggest that confusion between old matings and recent matings and between multiple old spermatophores and single fresh spermatophores are rare at Mexico overwintering sites. Confusion between multiple old spermatophores and single fresh spermatophores is expected to be a problem in summer breeders; where multiple mating is common, mating intervals are short, and activity levels are high (Suzuki and Zalucki 1986; Oberhauser, pers. comm.; Van Hook, pers. obs.). Because the mating event is more protracted in California (e. g. Hill et al. 1976; Tuskes & Brower 1978; Wells & Wells 1992; Leong et al. 1995) and mating can be common throughout the overwintering period at Australian overwintering sites (James 1993), palpation may also be of limited value at these sites. Confusion between very old matings and virgins is a significant problem in overwintering mating status assessments. This potential error can be overcome without need for dissection by combining palpation with counts of spermatophore stems that extend from the copulatory opening.

Palpation accuracy will depend on the initial size and degradation rate of the spermatophores and on female intermating interval (see also Oberhauser 1992). These, in turn, will vary with environmental conditions and physiological state. Just-transferred spermatophores were consistently classified as fresh for at least one week at the Mexican overwintering site studied in this paper. Weekly or shorter sampling intervals are therefore necessary to assess when the mass mating event begins and to describe changes in mating frequency through time using palpation. Studies of spermatophore degradation rates at different times in the overwintering period and calibration with bursa dissection mating status assessments could increase palpation accuracy in assessing mating status.

The relatively large size of recently obtained spermatophores (however, see Frey this volume regarding transfer of small spermatophores at Californian overwintering sites) and slow rate of deterioration, together with the brief nature of the spring mass mating period and the exponential nature of the increase in mating in the female population, suggest that palpation can be used to document the timing and intensity of the mass mating event. If a high degree of polyandry before the spring mass mating period is found to be rare in general at Mexico overwintering sites, as it was in Sierra Chincua (Van Hook 1993), palpation will also be useful in differentiating between spermatophores obtained during the mass mating event and those that occurred earlier in the migratory cycle. However, bursa copulatrix dissections are better able to differentiate between spermatophores that were obtained before and during the mass mating event.

Conclusions

Abdominal palpation and bursa dissection provide valuable and complimentary information that can be used to increase our understanding of monarch mating ecology. Together, abdominal palpation and spermatophore neck counts can be used in Mexico overwintering monarchs to: 1) delineate the timing and frequency of female mating during the mass mating period, 2) determine the total number of times an individual female mated, and 3) differentiate between virgins and non-virgins without injuring the female. Bursa copulatrix dissection is the best method to determine the relative timing of when females receive multiple spermatophores, especially when old spermatophores are very degraded. When dissections are necessary, comparisons of spermatophore neck and stem counts can improve estimates of the degree of polyandry and differentiation between virgins and non-virgins. These methods should be useful to study monarch mating ecology during other parts of their migratory cycle as well as other lepidopterans with migratory and aggregation life history phases.

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Poster presentation

Characteristics of and environmental influences on monarch mating behavior

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Abstract

Courtship behavior of monarch butterflies was observed during January to March 1997 at Pismo North Beach, California. Courtship consists of several stages or phases (see Frey this vol.) and this study examined the stages involving coupling attempts at ground level (struggle phase), the interval between coupling and nuptial flight (lag phase), and nuptial flight phase. Struggle duration was approximately four times longer than lag or nuptial flight durations (median 2.07, 0.52, 0.48, respectively). Struggle duration increased over the mating season. Lag duration was influenced by temperature, with longer lag times occurring in cooler conditions. The duration of a stage was not strongly influenced by the duration of behavior in previous stages, though struggle duration was positively correlated with lag phase duration. Mating attempts on ground substrate that had three dimensional structure (ice plant, leaf litter, grass) most often resulted in failure to couple whereas substrate providing little structure (i.e., gravel) was more likely to result in coupling.

Introduction

Urquhart (1960) carried out one of the earliest studies of monarch mating behavior. Fifteen years later, Pliske (1975) provided a more detailed description of monarch courtship. In the study reported here, some of the stages of monarch courtship as described by Pliske (1975) were used as a foundation and modified to allow documentation of durations of different behaviors. The hope was that from a broader understanding of these behaviors, future researchers would be able to focus on specific aspects of monarch courtship.

Monarch courtship is initiated by males and females are pursued and captured by one of two methods: aerial pounce or aerial pursuit (Pliske 1975; Hill et al. 1976; Leong 1995; Falco personal communication). Aerial pounce involves a male descending on a female resting in the tree canopy, whereas aerial pursuit involves a male capturing a flying female. Once the male captures a female the pair often fall to the ground where he attempts to couple with her in the ground phase struggle (Frey et al. 1998; Frey this vol.; Oberhauser & Frey this vol.). During this stage the male uses the tip of his abdomen to probe the female's body until his claspers contact her genital structures. Females often resist the mating attempts (Pliske 1975; Oberhauser 1992; Frey et al. 1998; Frey this vol.; Oberhauser & Frey this vol.), a behavior common to many insects (Thornhill & Alcock 1983). If the male is successful he clamps the female's genital structures and the female responds by folding her wings and becoming quiescent. The duration of the coupling attempt varies but appears to depend on the male's persistence and female's resistance to mating. After coupling, the male carries the female to a nearby tree, an activity commonly known as nuptial flight (Miller & Clench 1968). Following coupling and prior to flight, the male may pause briefly giving the appearance of rest (personal observations), and this is referred to here as the lag stage. Pairs remain coupled following the nuptial flight for 12 to 14 hours, during which the male forms a spermatophore in the female's bursa copulatrix (Pliske 1975; Svärd & Wiklund 1988; Oberhauser, personal communication). Nightfall or darkness has been suggested as a cue for sperm transfer (Svärd & Wiklund 1988).

The aim of this study was to obtain a quantitative and qualitative account of the ground phase and nuptial stage of monarch courtship. Several general and specific questions were addressed: (1) What is the mean duration of each stage in monarch mating? (2) Does the mean duration of each stage change as the mating season progresses? (3) Do temperature and ground substrate influence the duration of each stage or the outcome of mating attempts? I also determined if the durations of early stages influenced the durations of subsequent stages and could therefore be used as predictors of total courtship duration.

Study site

The study was conducted at Pismo North Beach Campground during the 1996–1997 monarch overwintering season. Situated in Pismo Beach, California, the Pismo North Beach Campground site is a popular monarch tourist attraction. The area of the site is 1.43 ha and is dominated by blue gum (*Eucalyptus globulus*) and Monterey pine (*Pinus radiata*) vegetation (Frey & Leong 1993). Of the 228 trees present, 207 are eucalyptus and 21 are Monterey pine (Smith 1993). The understory ground cover consists of ice plant and eucalyptus leaf litter. A graveled walkway meanders through the site. Human disturbance in the park is high during the overwintering and mating seasons. To the west of the park is the Pacific Ocean and to the east runs Highway 1. This site is subjected to moderate to strong ocean winds (Leong & Frey 1992).

Methods

Butterflies studied for analysis were associating pairs observed falling to the ground. From the point an associating pair reached the ground, temporal measurements of the mating behavior were recorded and included the following separate measurements: duration of ground phase struggle, duration of post coupling lag and duration of nuptial flight. All durations were measured to the nearest second, using a stopwatch. Mating attempts in which a male left or a female escaped were recorded as failed matings. Air temperature was measured with a Celsius thermometer and contact surface type was recorded as either gravel, grass, leaf litter or ice plant *Cryophytum crystallinum*. Data were collected approximately three times per week between 08:00 and 17:00 PST.

Results

Between 27 January 1997 and 7 March 1997, 199 mating attempts were observed. All analyses of durations are based on $\log_{10}$ transformations and assumptions of normality.

Ground phase struggle

Ground phase struggle duration ranged from 0.03 to 45.82 minutes (refer to table 1). The frequency distribution of ground phase struggle durations (Figure 1) showed that nearly 70% of the struggles lasted less than 4.5 min and the median value is 2.07 min. Regression analysis indicated an increase in ground phase struggle duration over the season ($P = 0.007$, $R^2 = 0.060$). However, since only 6% of the variation in ground phase struggle duration was explained by the variation in season, the association was weak.

Table 1 Summary of the durations of ground struggle, lag and nuptial flight phases, recorded between Jan. – Mar. 1997 at Pismo North Beach Campground overwintering site

Stage	Mean (min.)	S.E.	Median	Max	Min	n
Struggle	3.95	0.44	2.07	45.82	0.03	198
Lag	4.50	1.89	0.52	140.38	0	79
Nuptial fl.	0.69	0.12	0.48	7.48	0.12	73

Multiple regression analysis of the influence of temperature and ground substrate type (included in the analysis as dummy variables) on ground phase struggle duration indicated no association ($P = 0.417$, $R^2 = 0.1$). The same result was obtained when the category of ground substrate type was broken down into just two groups, one with three dimensional structure (grass, leaf litter and ice plant), that could provide interference to the coupling attempt by a male and one without three dimensional structure (gravel), that would not provide interference and tested with temperature (multiple regression; $P = 0.095$, $R^2 = 0.018$).

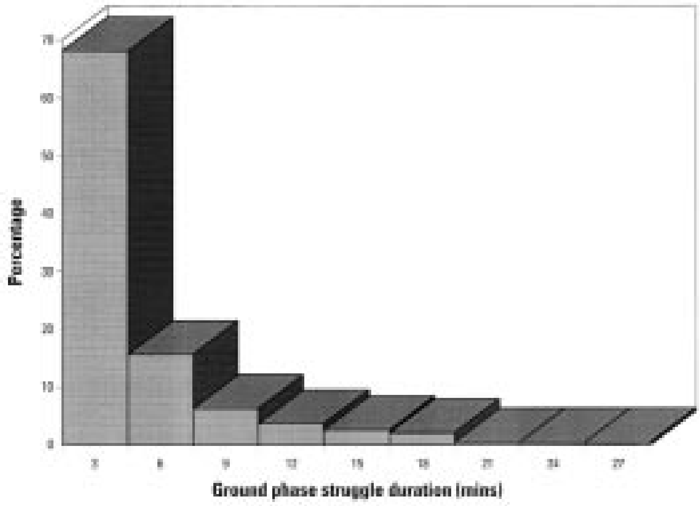

Figure 1. Frequency distribution of ground phase struggle durations recorded between Jan. – Mar. 1997 at Pismo North Beach Campground (n = 190). Extreme values have been omitted to permit easy reading of the graph.

Lag phase

Lag duration (i.e. the time between coupling and take off for nuptial flight) ranged from 0 to 140.38 minutes with a median duration of 0.52 min (refer to Table 1). The frequency distribution is given in Figure 2. Lag duration did not change over the mating season (Regression analysis, $P = 0.2202$, $R^2 = 0.032$). A multiple regression analysis of the influence of temperature, ground substrate type and ground phase struggle duration on lag duration indicated that a significant association exists ($P < 0.001$ and $R^2 = 0.365$). Three terms in the model accounted for this predictor relationship. Temperature was found to be the strongest predictor (Table 2; step 1, $T = -4.24$) and gave an inverse; higher temperatures were associated with shorter lag durations. The second strongest predictor variable in the presence of temperature was the duration of struggle phase (Table 2; step 2, $T = 3.11$). Attempts with longer struggle durations had longer durations of lag and vice-versa. The third predictor, given that temperature and ground phase struggle are included in the model, was an interaction between substrate type and temperature (step 3). This suggests that the effect of temperature (step 1) is complex and or different depending on the type of substrate the attempt takes place on.

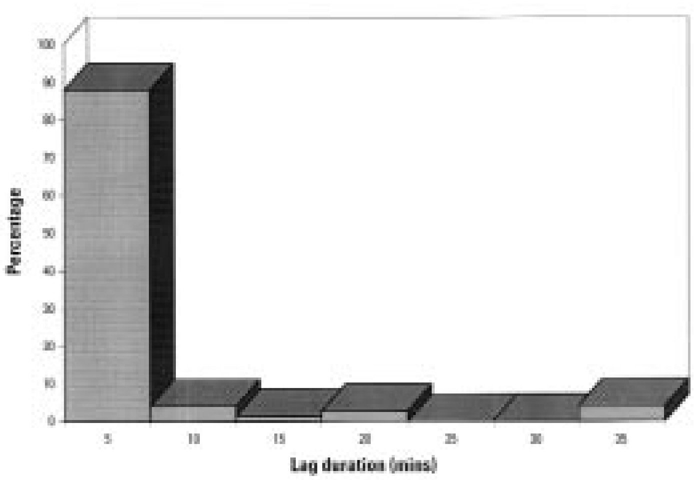

Figure 2. Frequency distribution of lag durations recorded between Jan. – Mar. 1997 at Pismo North Beach Campground (n = 74). Extreme values have been omitted to permit easy reading of the graph.

Table 2 — **Results of stepwise regression analysis of temperature, substrate type and ground struggle duration on lag duration**

Variable		Step 1	Step 2	Step 3
Temperature:	coefficient T	-0.10 (-4.24)	-0.080 (-3.48)	-0.066 (-2.95)
Ground Phase Struggle:	coefficient T		0.56 (3.11)	0.58 (3.41)
Temperature X Substrate Interaction:	coefficient T			-0.031 (-3.06)
R^2 for step:		*20.01*	*29.57*	*37.90*

Note: P (For overall model) = < 0.001
$R^2 = 0.365$

Nuptial flight

Nuptial flight duration ranged from 0.12 to 7.48 min with a median duration of 0.48 min. The frequency distribution is given in Figure 3. Flight duration did not change over the mating season (Regression analysis, $P = 0.946$, $R^2 = 0.00007$). Multiple regression analysis of ground phase struggle duration, lag phase duration and temperature on nuptial flight duration also showed no significant relationship ($P = 0.249$, $R^2 = 0.034$).

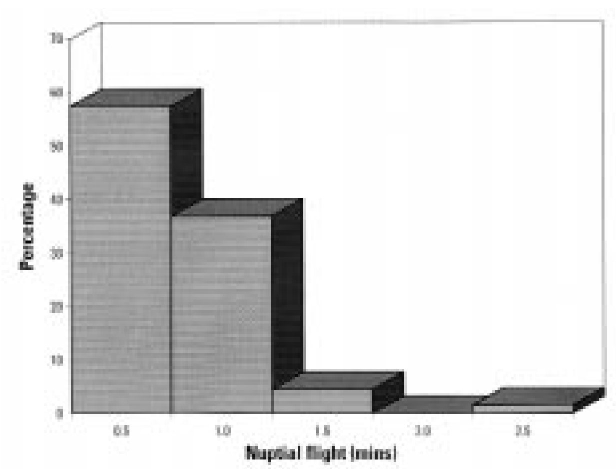

Figure 3. Frequency distribution of nuptial flight durations recorded between Jan. – Mar. 1997 at Pismo North Beach Campground (n = 68). Extreme values have been omitted to permit easy reading of the graph.

Mating success and failure

The mean temperature at which struggles resulted in coupling (success) or separation (failure) was similar (17.8ºC and 18.6ºC respectively). This indicates that temperature was not a predictor of the outcome of a male mating attempt ($T = -1.16$, $P = 0.25$).

Mating attempts ended in coupling 54% of the time on gravel, but only 32% of the time on ice plant, leaf litter and grass. Chi square analysis was carried out to determine whether ground substrate had an influence on the outcome of a mating attempt. Males were more successful in coupling with females on substrate that provided little interference (i.e., gravel), compared to ice plant, leaf litter and grass, which could provide interference to mating (df = 1, $P = 0.005$).

Discussion

The duration of ground phase struggle was longest, lag duration second longest and nuptial flight the shortest (Table 1; 2.07, 0.52, 0.48 min respectively). This result shows that ground phase struggle duration can take approximately four times longer than the durations of lag and nuptial flight. Ground phase struggle is the determinant stage (i.e., outcome of this stage determines whether the episode continues to the next phase), therefore males are expected to persist in the attempt, since failure to couple means initiating a new courtship sequence, and for females the unwanted mating may have significant costs. Ground phase struggle involves much maneuvering and may have high energetic costs for both sexes. During the lag phase, butterflies appear to be resting with minimal movement. If this phase is a time of recouping, long struggles should be followed by long lag phase duration and *vice versa*. Lag duration was positively influenced by ground phase struggle duration; longer struggles resulted in longer durations of lag, provided temperature was included in the model (see Table 2). Lag stage may be particularly important to a male as he must subsequently carry out another energetically expensive behavior, nuptial flight. The costs of these two behaviors may partially explain the differences in duration of struggle and nuptial flight.

Although energy cost relationships predict that longer struggles would result in longer periods of rest (lag) and that shorter struggles would have shorter periods of rest and or result in longer flights to more secluded areas, the results indicate that the duration of one stage is not a strong predictor of the duration of another. It is a complex relationship which may involve several other factors, such as weight of individuals, health of each partner, harassment from other butterflies or predators, such as wasps (observed at this overwintering site), as well as humidity and wind. These variables need to be addressed in future studies.

Of the three behaviors, only ground phase struggle duration increased as the season progressed. One possible explanation for this result is that females later in the season may have contained more and or larger spermatophores. This is expected to result in greater resistance to mating attempts, that in turn result in longer struggle durations (see Frey, this volume; Oberhauser and Frey, this volume).

In this study, I addressed the effects of two micro-environmental factors that were thought to influence mating behavior: temperature and ground substrate type. Ground phase struggle and nuptial flight behaviors were found to be independent of temperature. Lag duration was influenced by temperature, with longer lag times occurring in cooler conditions. In some coupled pairs males may display shivering behavior and move (drag the female) towards a sunny location on the ground (Masters et al. 1988; personal observations). Warmer temperatures increase the body temperature that in turn allows rapid muscle activity for flight. It is known that at around 12–14ºC an increase in one degree of temperature can be the difference between movement (including flight) or remaining motionless for monarch butterflies (Masters et al. 1988). Although temperature had no direct influence on ground phase struggle and nuptial flight behaviors, it is an important variable that influences several aspects of monarch biology (Masters et al. 1988; Masters 1993). The mating process is complex; it appears that environmental variables may not on their own have significant effects, but may contribute along with other variables to individual behavior. It could also be that some behaviors may operate on a temperature threshold, in which temperatures above or below would not have a significant effect on the duration of the behavior. The fact that all of the struggles I observed occurred at temperatures above 10ºC may explain the results of my analysis.

Temperature had no influence on the outcome of mating attempts, but ground substrate did. It should be noted that in some cases females became wedged in ice plant, grass or leaf litter in such a manner that the tip of their abdomens were exposed, allowing easier coupling. However, matings on gravel surface were more likely to end in coupling, whereas mating on substrate that could provide retreats or hiding places for the female were more likely to result in separation of the pair. This indicates that the environment has some influence on monarch mating and that characteristics of the butterflies alone do not govern mating behavior.

Conclusion

Monarch courtship is a lengthy, dynamic process involving several discrete stages or steps. It is influenced by both temperature and ground substrate type but the relationships are complex, indicating probable influence from other biological and environmental factors (for example see Oberhauser & Frey, this volume).

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Patterns in the monarch butterfly migration through Texas—1993 to 1995

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Abstract
Each year, monarch butterflies migrate from summer breeding grounds in the United States and Canada to overwintering grounds located in a small circumscribed area of the Transvolcanic Range of Central Mexico. To define the migratory pathway through Texas, we established an information exchange service called the Texas Monarch Watch among volunteers during the falls of 1993–5. Compiled data for these years showed that monarchs do not traverse the state in a homogeneous manner, but rather confine themselves to two flyways that are separated spatially and temporally. One flyway passes roughly north to south through the center of the state, while the other flyway follows along the Gulf of Mexico. Problems inherent in using volunteers to report the presence and abundance of monarchs are discussed.

Introduction
The annual cycle by which the monarch butterfly (*Danaus plexippus* L.) vacates and repopulates eastern North America, and the routes of travel from breeding areas to overwintering areas are not well known. During summer months monarchs breed in northern states and provinces, roughly between latitudes 35 and 50º N (Urquhart 1987, Malcolm et al. 1993). In August or early September, monarchs begin to experience conditions unfavorable for breeding, and newly eclosed adults are mostly reproductively dormant (Herman 1985). As the season progresses from late August to September, more and more are seen in migration southward across continental North America. When they reach the Mexican Sierra Madre Oriental or the southern Rocky Mountains, they change direction to follow the axis of those mountains (Calvert in review). Their trek across the continental United States carries them to the south or southwest depending on their point of origin (Schmidt-Koenig 1985, Urquhart 1987, Rogg et al. this volume), while in Mexico they travel primarily south-southeastward through the desert and mesic montane valleys of the Sierra Madre Oriental. They continue along these valleys, crossing the ranges progressively westward, until they reach the nine or so sites in the transvolcanic mountains of south-central Mexico (Calvert in review).

We know that the principal breeding grounds of the monarch are in the northern United States and southern Canada, and that monarchs greatly increase their numbers there, but we don’t know much about milkweed distribution and breeding success in northern states and Canadian provinces. In particular, we don’t know whether breeding is continuous across the north or patchy. If fall monarchs breed homogeneously throughout the north, we should expect some sort of homogeneous passage across the country towards Mexico, at least initially. If breeding is patchy, where are the patches and how do they influence the migration routes? If breeding in the north is not homogeneously distributed, some locations are likely to be more important for monarch breeding than others, and these areas will contribute more monarchs to the migratory pathway.

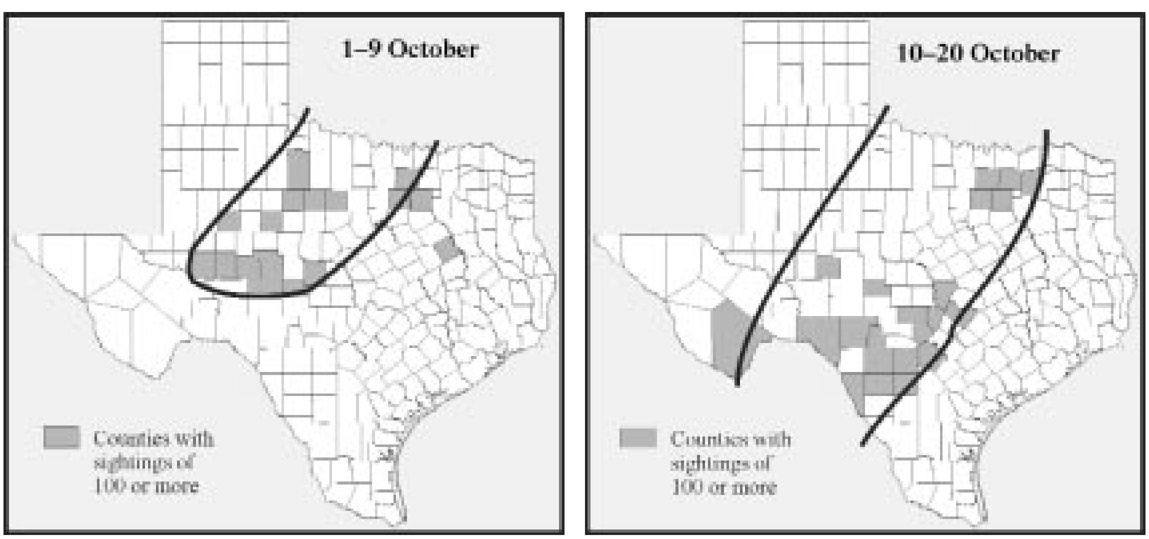
We began a study of the migration through Texas using as a starting point the hypothesis that monarchs breed homogeneously and therefore migrate in equal densities between the Great Plains and the Atlantic Ocean. Texas was ideal for such a study because the vast majority of monarchs that migrate to Mexico are likely to pass through it. There is some recent evidence that monarchs that breed in certain areas west of the Rocky Mountains may also make their way to South-central Mexico (R. Pyle pers. comm.). Still more recently, evidence has emerged that shows that some eastern monarchs fly to the Caribbean (L. Brower pers. comm.). Notwithstanding these reports, the number moving through Texas is vast by comparison.

Methods

We established the Texas Monarch Watch in 1993 using the example of the Monarch Watch, founded in 1992 by Chip Taylor and Brad Williamson (Taylor 1993–7; Taylor this volume). A unique feature of the Texas Monarch Watch is a toll-free "hotline," which volunteers call to hear current news of the migration and report descriptions of events that they witness. In many cases, we received instantaneous reports of events. We also sent out calendars covering dates from mid-September to mid-November on which volunteers were asked to mark the numbers of monarchs passing through their area. At the end of the season, we compiled the information from the hotline and calendars and sent the participants a newsletter account of the progress of the migration through Texas.

To solicit observers, we periodically issued press releases. Articles, which described the program and called for volunteers, appeared in newspapers throughout the state. We also placed short notices describing the program in several newsletters dedicated to environmental teaching. We further publicized the program by appearing in televised news shorts and by speaking at local clubs and schools. In response to requests for information, we sent out an information packet describing the program and the requirements of the volunteers. Information packets with tags were also made available to Texas schoolteachers through the Science Materials Center.

The data used in the maps of Figure 1 differ from those used in the Tables. To insure that a significant migration was in progress, only sightings of 100 or more monarchs at one location were plotted in the maps of Figure 1. These 100 or more butterflies could be either one-time observations or the result of accumulated observations during the course of one day.



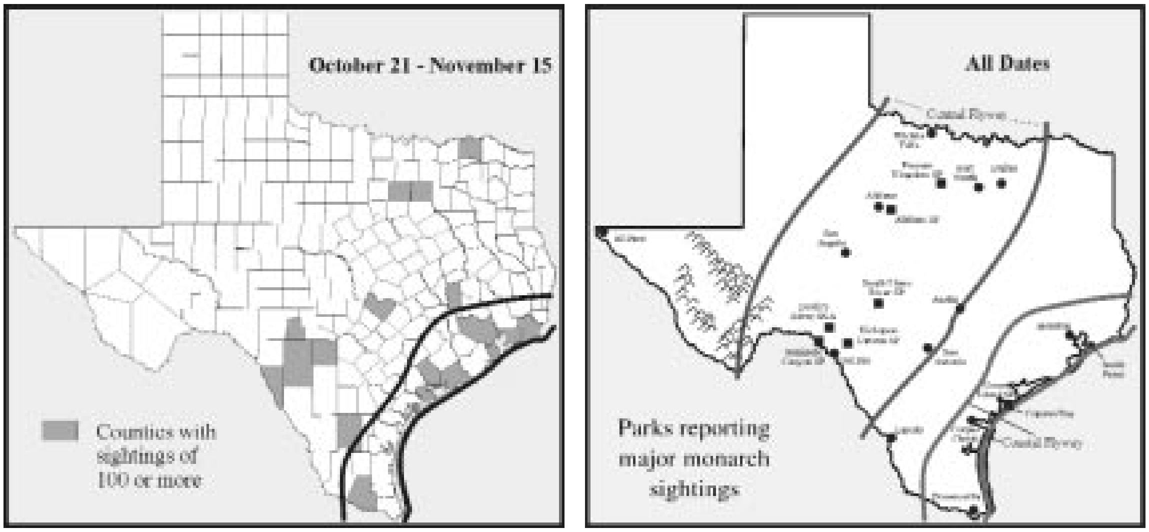


Figure 1 a–d. Texas counties where more than 100 monarch butterflies were seen during one day during the 1993 fall migration. Fig. 1 a–c show a progressive movement of monarchs through Texas beginning in north-central Texas around 1 October and ending along the Texas coast in mid-November. Fig. d is a composite of Figs. 1 a–c, showing the central and coastal flyways and the cities, parks and some physiographic features mentioned in the text.

Tables 1 & 2 represent data from all reports, including those of fewer than 100 individuals. The number of volunteer reports during the three-year period ranged from a low of 71 in 1993 to a high of 88 in 1994. Reports varied in coverage from daily recordings of monarch presence (or absence) for much of the two-month period to single observations. Peak passage dates were averaged to calculate the time of peak passage for the central and coastal areas (Table 1) and the latitudinal and longitudinal ranges (Table 2). When available, peak passage times were derived from calendars that had continuous or nearly continuous records over the two-month period. Such calendars showed a progressive rise of monarchs spotted followed by a decline. Ideal records, such as these, were not always available. Single observations of high numbers were also used in the computation of peak passage times. In cases of low numbers, care was always taken to use only records that showed a true peak. For example, those records with low numbers scattered over a wide range of dates showing no rise and decline were excluded from the average. Occasionally however, due to longitudinal and latitudinal restrictions, only a single observation was available to derive a passage time, e.g., in the left column of Table 2.

Table 1 — **Mean number of monarchs seen per observation day and mean date of passage: Central vs. Coastal Flyway**

	Central flyway		Coastal flyway	
1993	1,320[a]	N = 63[b]	357	N = 8
	11 Oct[c]		27 Oct	
1994	364	N = 75	39	N = 13
	10 Oct		27 Oct	
1995	1,868	N = 44	14	N = 23
	10 Oct		13 Oct	

[a] Mean number of monarchs seen per peak day.
[b] Number of volunteers reporting that season. All reports are counted, not just those with observations of 100 monarchs or higher.
[c] Mean date of peak passage.

In Table 2, the first longitude column represents sightings outside the migratory flyway to the west and the third column represents sightings outside to the east. The center column represents swath of terrain 4.9º longitude or approximately 543 km (337 miles) wide that moves 0.63º longitude west for every degree of latitude traversed southward and contains virtually all of the observed sightings. Although the central flyway continues to contain the majority of butterflies, south of latitude 30º N the percentage of monarchs east of the flyway increases. These are the monarchs flying along the Texas Coast.

Table 2 **Sightings of migrating monarch butterflies as a function of latitude and longitude for the years 1993–95 combined**

Latitudinal range	Longitudes: west of flyway	Longitudes: central flyway	Longitudes: east of flyway	Total observed[a]	% in central flyway
33.1 to 34	>100.1º	100–95.1º	<95.0º	27,000	99
	N = 1[b]	N = 20	N = 0		
	200[c]	1,300			
	5 Oct[d]	6 Oct			
32.1 to 33º	>100.7º	100.6–95.7º	<95.6º	9,000	99
	N = 1	N = 30	N = 2		
	12	289	19		
	21 Sept	7 Oct	16 Oct		
31.1 to 32º	>101.4º	101.3–96.4º	<96.3º	6,000	91
	N = 4	N = 24	N = 3		
	13	229	169		
	10 Oct	5 Oct	13 Oct		
30.1 to 31º	>102º	101.9–97.0º	<96.9º	11,000	99
	N = 4	N = 27	N = 3		
	17	401	6		
	3 Oct	11 Oct	31 Oct		
29.1 to 30º	>102.6º	102.5–97.6º	<97.5º	128,000	99
	N = 4	N = 44	N = 21		
	166	2,867	45		
	11 Oct	14 Oct	11 Oct		
28.1 to 29º	>103.3º	103.2–98.3º	< 98.2º	16,000	77
	N = 0	N = 8	N = 12		
		1,560	303		
		18 Oct	1 Nov		
			Total	**190,000**	

Note: All sightings are in Table 2, including those less than 100 per day.

[a] Rounded to nearest thousand.

[b] Number of observations in latitudinal and longitudinal ranges.

[c] Mean number of monarchs sited in latitudinal and longitudinal ranges. (On two occasions there is only a single observation).

[d] Mean date of passage in latitudinal and longitudinal range.

Once a year during the three-year period, we drove transects perpendicular to the migratory path way to “ground-truth” the accuracy of the volunteer reporting method.

Results

During 1993–95, the main body of migrants arrived in Texas in late September or early October. Between 1 and 10 October, the majority of volunteers who reported 100 or more monarchs seen in one day were located in north-central Texas counties. Between 11 and 20 October, reports of activity had largely shifted to the southwestern part of the state and to Coahuila, Mexico. After 20 October some activity remained in the center of the state, but much had shifted to the coastal area. On the basis of the distribution of these observations, we proposed two separate flyways through Texas: one passing through the middle of the state centered on a line beginning on the Red River approximately 60 km east of Wichita Falls to Del Rio; and the other passing along the coast from Louisiana to Mexico. Figure 1 a–c shows this progressive passage of monarchs through the state for the year 1993.

Between 1 and 20 October, volunteers in the central flyway consistently reported large numbers of monarchs (Table 1). Roosting or over-flights consisting of thousands of individuals were nearly always observed in or near cities such as Abilene and San Angelo and State Parks such as Possum Kingdom, Abilene, Kickapoo Caverns, Seminole Canyon, Devils River and South Llano River. Kickapoo Caverns reported 110,000 one year and a rancher in Nolan County south of San Angelo reported a quarter of a million. We have no idea how accurate these counts were, but we may conclude that there were a lot of butterflies!

We defined the central flyway more precisely by locating a swath of terrain that encompassed the majority of the sightings. To do this, we first plotted the distribution of major sightings and then drew a line through the center of the distribution. We found that a swath of terrain 4.9º of longitude or approximately 543 km (337 miles) wide that moved 0.63º longitude west for every degree of latitude traversed southward contained virtually all of the observed sightings (Table 2).

The coastal flyway showed much more yearly variation than the central flyway (Table 1). The year of 1993 was exceptional for the coastal migration. Monarchs were reported to be migrating by the thousands in several places around Copano Bay and Corpus Christi (Table 1; Fig. 1c). In contrast, during both 1994 and 1995 much less activity was reported.

The central flyway has proved to be very reliable with respect to consistency of the time of peak passage (Table 1). Each year, the average time of peak passage for the whole state occurred on either 10 or 11 October. In contrast to the predictable central flyway, the average time of peak passage for coastal migrants varied among years (Table 1). The average date of passage was 27 October in 1993 and 1994, but it occurred two weeks earlier in 1995.

The boundaries of the central flyway meander from year to year and during any one year the flyway may be narrower than other years. Visual estimates based on yearly distributions of plotted sightings indicate that the 1994 and 1995 flyways were approximately 90 km and 110 km to the east of the 1993 flyway respectively.

Discussion

On the basis of the data provided by Texas Monarch Watch volunteers, we reject the hypothesis of a homogeneous migration across the United States. The circumscribed flyway through the center of Texas does not support a homogeneous migration. We hypothesize that the larger central flyway contains butterflies that have bred in the western mid-western states, roughly from the eastern Dakotas to Michigan, and that the smaller coastal flyway represents butterflies that have bred in eastern states, perhaps from Maine to the Carolinas. The delay in appearance of monarchs along the Texas Coast is likely due to the greater distance that the eastern monarchs must travel from their breeding grounds.

At least two mechanisms might account for the discreet flyways. Migrant movement may be focused along the way by physiographic features such as river valleys and mountains that turn or channel the migration. The most obvious possibility is the Gulf Coast. Butterflies migrating southwest, for example, from the Central and South Atlantic States would be expected to strike the Gulf at some point during their southwesterly migration. If they turned to follow the coast westward, there should be ample migration along the Texas coast at some time during the fall. However, Rogg et al. (this volume), examining mark and recapture data from Urquhart and the Monarch Watch, show evidence that suggests that monarchs adjust their flight directions independently of physiographic features.

No physiographic features that seem likely to focus the flyway are present in the landscape between mid-western breeding areas and the Texas central flyway. All of the major rivers, with the exception of the Mississippi, run perpendicular or nearly perpendicular to the migratory path. Although the Mississippi River valley runs north-south, it is not oriented properly to channel migrants into the central flyway, which lies a considerable distance to the west.

Another possibility is that breeding in areas of the North-central United States and Canada is more concentrated than elsewhere, and hence, more butterflies eclose and migrate in a corridor, the southern extent of which is the central flyway in Texas. This is an area of former prairies, large portions of which are in extensive corn and soybean cultivation in which milkweed densities are expected to be high (O. Taylor, pers comm.).

A lack of a strong migration along the Texas Coast during any particular year would suggest a decline in breeding activity in the purported source areas in Northeastern or Central Atlantic States. These data predict that 1993 should have been a good year for eastern monarchs and that 1994 and 1995 should have been poor years (Table 1). However, the hypothesis that Texas coastal migrants represent those that have bred in Atlantic States is not well supported by other studies. Steffy (1998) compares three independent estimates of the size of the population in the Northeast: one she conducted in southern Pennsylvania, one at Cape May, New Jersey (Walton & Brower, 1996; Walton, 1997) and the Fourth of July Butterfly Count (Swengel & Opler, 1996). In her analysis, Steffy restricted her examination of Fourth of July count data to the Northeast, east of longitude 80º W and north of latitude 40ºN, the area where butterflies passing through her area presumably bred. All three estimates showed the highest population size in 1994, a low count year for the Texas Coast. The first two estimates predicted a low population in 1995, which agrees with the results derived from observations along the Texas Coast, but the Fourth of July counts predicted a moderate population in 1995, higher than 1993 and lower than 1994. More years of study will be necessary to discover the source of monarchs traveling along Texas Coast and to verify the existence of a coastal flyway.

The use of “untrained” volunteers has inherent problems. First among them is the variation in skills in estimating population numbers. We encouraged volunteers to report actual numbers and to avoid using words like “few” and “many” that are hard to interpret. What accuracy can we expect of anyone’s count of a tree-full of roosting monarchs or a sky-full migrating through? We recognize that the observations reported here are not precise numbers and should be considered to be of relative value rather than an actual measure.

Another, perhaps more serious, problem concerns the relationship between the spatial distribution of observers and reported butterfly presence and abundance. Volunteer observers were not distributed equally over the state. Many more reports came from urban centers than rural settings. Moreover, the presence of large numbers of monarchs stimulated the volunteers to report what they saw. Does over-representation of urban centers and stimulation to report by the presence of monarchs skew the results? We think not, for these reasons. Yearly transects across the butterfly pathways confirmed that butterflies are abundant in the areas where observers reported large numbers and are rare in areas not reporting them. Also, certain persons who lived in areas where monarchs were rare or absent and whose observational skills we trusted were asked to pay special attention during the migration period. Their reports of low numbers confirmed the existence of a major flyway in which nearly all monarchs fly.

Conclusions

The migration across Texas is not homogeneous. Monarchs are concentrated in a central flyway, and perhaps a coastal flyway. We will have to look further north for clues as to what creates these immense channels of migrating monarchs.

Acknowledgments

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Testing monarch butterfly orientation in the field during the autumn migration

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Abstract

Monarch butterflies east of the Rocky Mountains migrate great distances of up to 4,000 km in the fall to travel from their breeding grounds in the United States and Canada to their overwintering sites in Mexico. The mechanisms of orientation that allow the butterflies to find their way south have remained mostly unknown. One possible mechanism, a sun compass, was tested in a clock-shifting experiment in the field. The butterflies were clock-shifted by six hours and their subsequent flight orientation was measured both in terms of their heading and their vanishing bearing. The heading of clock-shifted migrants was shifted in the predicted clockwise direction when compared with that of both sham controls and natural controls. Vanishing bearing measurements, which have traditionally been used in orientation studies for other species, were less robust to the effect of wind than heading measurements. Measuring heading of subjects allowed a test of their behavior that would have been impossible using vanishing bearing data alone. This study indicates that monarch butterflies use a sun compass to orient on the southbound migration.

Introduction

Monarch butterflies migrate south in the fall from summer habitats throughout central and eastern United States and Canada to overwintering sites in central Mexico. For decades, this phenomenon has been recognized and studied primarily through mark-recapture studies and non-manipulative observations of natural migrants (Urquhart 1941; Schmidt-Koenig 1993; Brower 1996). Despite considerable speculation on the subject (Gibo 1981; Gibo 1986; Kanz 1977; Schmidt-Koenig 1985), the means by which these naive insects orient during their long journey remained a mystery. Here we test experimentally whether migratory monarchs use the sun's changing azimuth as a directional cue.

In addition to butterflies, migratory animals such as birds and ants all face the same orientational problems and may be expected to converge on a similar orientation mechanism, the use of a sun compass (Berthold 1993; Frisch 1967; Oliveira et al. 1996; Oliveira et al. 1998; Papi 1992; Wehner et al. 1996a). In conjunction with knowledge of time of day, these animals are able to use the sun to orient their migratory and homeward movements. Importantly, the relevant navigational feature is the sun's azimuth, i.e. the horizontal component of position, and not its height in the sky (Frisch 1967; Kramer 1953). The animals are able to take a particular migratory heading with respect to the sun's azimuth.

The sun's azimuth changes during the course of a day, but the direction of migration does not. Therefore, if the sun is being used as a directional cue, the animal's behavior with respect to the sun must change in order to maintain a constant migratory heading. In the morning, the sun's azimuth is in the east. At this time of day, to head south, a Mexico-bound monarch would fly with the sun's eastern azimuth on its left side. By noon, the sun's azimuth has moved to the south, and the migrant would maintain its southerly heading by flying toward the sun's azimuth at this time of day.

Beginning with Schmidt-Koenig (1958), experimenters have demonstrated sun compass use by clock-shifting subjects. This change in internal clocks causes the animals to misinterpret the position of the sun and change their direction of movement in a predictable way. If a migratory butterfly were to undergo an internal clock delay, it would misinterpret the sun's southerly noon position as the easterly morning position. The experimentally clock-delayed migrant, by mistakenly keeping the sun on its left side, would head west, exhibiting a clockwise change in orientation. In this study, we experimentally clock-shifted (delayed) migrating monarchs and measured their subsequent direction of orientation to determine whether these butterflies use a time-compensated sun compass to orient their migratory flight.

Methods

We captured 200 monarch butterflies during three evenings (12–14 Sept. 1996) at known migratory roosting sites along the Kansas River in northeastern Kansas, USA (39.963º, -95.233º). We brought the migrants to the lab and separated them into two groups: a clock-shifted treatment group and a sham control group. We delayed the photoperiod of clock-shifted butterflies by a quarter of a day (6 hours). Isolated from any natural light, these clock-shifted subjects experienced the start of their photoperiod at 13:00 and the end at 24:00. The sham control butterflies experienced the start of their photoperiod at the normal time in the morning (07:00). Migrants self-fed on artificial nectar[1] with honey and water in several cages measuring between 0.5 m^3 and 1 m^3. We tested subjects that had been acclimated to the lab's light-dark cycle for a minimum of nine days and a maximum of 15 days. Monarch butterflies can adapt to a 6-hour delay in light-dark cycle in as little as two to four days (Perez unpublished data).

We released experimental subjects individually on cardboard "launch pads" in an open field at the University of Kansas under mostly sunny conditions. In order to avoid an undirected escape response, butterflies were kept cool (0–4ºC) while awaiting release (20–90 min). Once a migrant began directed flight, we watched it for approximately 1–5 minutes and made two measurements using hand held compasses. First, when possible, we recorded horizontal body orientation which is the direction in which the butterfly's head points in flight (hereafter HEADING). Second, we recorded vanishing bearing (hereafter BEARING) which is the point on the horizon where a subject disappears from sight. Naturally migrating butterflies that passed through the same open field served as the experiment's natural control group. We recorded BEARINGs and, where possible, HEADINGs for these natural controls. Migratory HEADINGs were more difficult to measure than the BEARINGs but could be estimated for over half of the subjects (272 of 532) by walking behind or beneath the flying monarchs and taking a reading once the butterflies' behavior stabilized. Observers were careful to avoid eliciting an escape response by not casting shadows on subjects nor following subjects too closely. Subjects that did not exhibit directional flight due to spiraling on thermal currents, stopping to feed, etc. were excluded from the analysis. We also measured wind speeds and directions using a hand held anemometer. We performed a declination correction (7º W for Lawrence, KS, USA) on all direction measurements, and we report times based on Central Standard Time (CST) rather than Daylight Savings Time to simplify estimates of sun position.

Results

Clock-shifted butterflies exhibited a mean HEADING toward the WNW (Fig. 1A), which differs from the mean SSW orientation of the sham controls by 75º (Watson's F-test; $F = 13.84$; $p < 0.001$) (Fig. 1B) and differs from the mean natural control measure by 85º ($F = 49.02$; $p < 0.001$) (Fig. 1C). The clock-shifted butterflies exhibited a mean HEADING that was shifted in the predicted clockwise direction based on the time delay these butterflies experienced. Furthermore, in addition to the direction, the magnitude of the shift is also that predicted by the quarter day time shift. Importantly, the two control groups exhibited similar mean HEADINGs ($F = 1.93$; $p >> 0.05$) (Fig. 1B and 1C), indicating that there was no significant effect of captivity or chilling on this measurement.

[1] Artificial nectar contains 300g sucrose, 8g ascorbic acid, 4g sorbic acid, 4g methylparabenzoate, 3 pinches pollen and 2000ml distilled water. The pH was increased to 3.5–4.0 with potassium hydroxide.

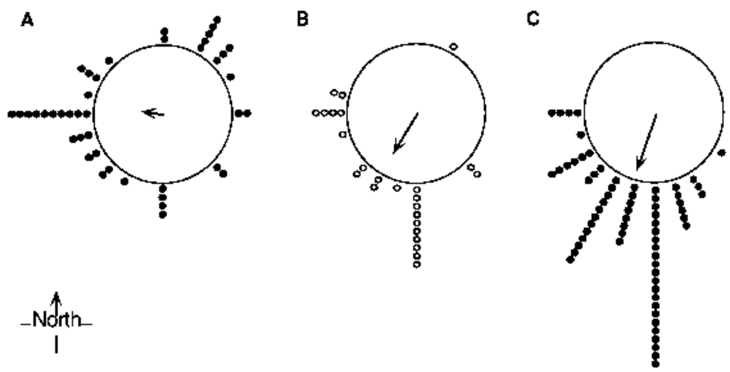

Figure 1. HEADING data and resultant vectors for clock-shifted migrants ($\mu=287$º; r = 0.29; n = 43, each circle represents one migrant), sham controls ($\mu=211$º; r = 0.67; n = 25, each circle represents one migrant) and natural controls ($\mu=200$º; r = 0.86; n = 204, each circle represents three migrants). Subjects not exhibiting directional flight for any reason (e.g. spiraling upward on thermal currents, stopping to feed, etc.) were excluded from the analyses.

Natural controls exhibited a mean SSW HEADING (200º) (Fig. 1C) that was remarkably convergent with the group's mean BEARING (202º) ($F=0.37$; $p >> 0.05$) (Fig. 2C), suggesting that, in the absence of a chilling treatment, HEADING is a good estimator of ultimate BEARING. Clock-shifted butterflies' mean BEARING (Fig. 2A) differed from both the sham controls' ($F=10.67$; $p<0.01$) (Fig. 2B) and the natural controls' ($F=293.74$; $p<0.001$) (Fig. 2C).

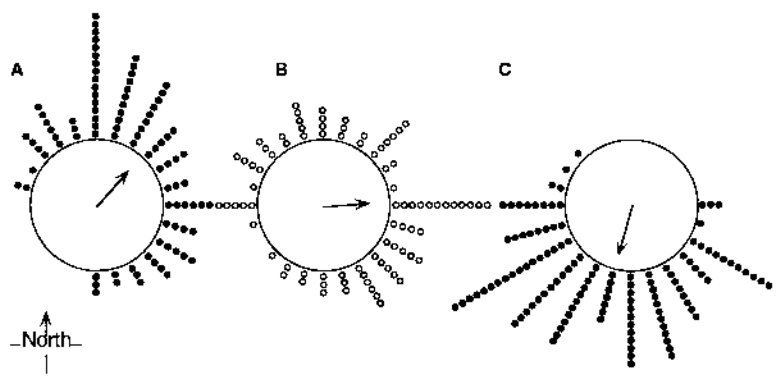

Figure 2. BEARING data and resultant vectors for clock-shifted migrants ($\mu=38$º; r = 0.47; n = 94, each circle represents one migrant), sham controls ($\mu=86$º; r = 0.23; n = 82, each circle represents one migrant) and natural controls ($\mu=202$º; r = 0.67; n = 356, each circle represents two migrants).

Cross-winds had a weak but statistically significant effect on the natural migrants' HEADINGS. The HEADINGS of butterflies which experienced winds directly out of the east (90º) (Fig. 3A, open circles) was somewhat different from that of those experiencing winds directly out of the west (270º) (Fig. 3A, closed circles) ($F=6.39$; $p<0.01$). Contrary to expectations, monarchs did not compensate for cross-winds by flying into them, but rather slightly reoriented their bodies with the direction of the wind. Most natural migrants we observed, however, continued to face generally southward regardless of wind direction. BEARINGS, in contrast to HEADINGS, were more strongly affected by cross-winds ($F=211.93$; $p<0.001$) (Fig. 3B). Interestingly, the wind effect was less pronounced for the natural controls. These unmanipulated animals were better at maintaining their SSW course (Fig. 2C) than were the previously captive and chilled sham controls (Fig, 2B) ($F=85.7$; $p<0.001$). This disparity in wind compensation is most likely due to the chilled subjects' being at minimum threshold temperatures for flight and, therefore, being temporarily too weak to correct for wind effect. Provided the winds were slower than 24 km/h, three points seemed clear: 1) migrants continued to move despite unfavorable winds, 2) migrants partially compensated for unfavorable winds and 3) migrants may have detected favorable winds and "surfed" toward their overwintering sites (Gibo 1981, 1986; Walker & Riordan 1981; Walker 1985).

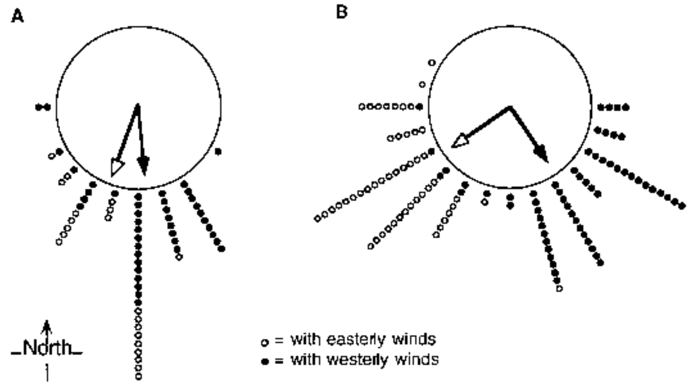

Figure 3. Effect of easterly and westerly winds on (A) HEADING (NE = 21; NW = 42) and (B) BEARING (NE = 50; NW = 60) data for natural controls. Open circles indicate individuals which experienced winds out of the east. Closed circles, wind from the west. Each circle represents one migrant.

Naturally migrating butterflies maintained HEADINGs and VANISHING BEARINGs that were approximately SSW throughout the course of the day. Mean measurements for groups released in the morning (09:00–10:30 CST), early afternoon (13:00–14:30 CST) and late afternoon (15:15–16:30 CST) ranged from 196º to 216º, well within the southwestern quadrant. HEADINGs and BEARINGs for natural migrants were the same in the morning (Fig. 4 A1 and B1) as they were in the late afternoon (Fig. 4 A3 and B3) (HEADING: $F = 0.83$; $p >> 0.05$; BEARING: $F = 0.01$; $p >> 0.05$). HEADING and BEARING measurements taken in between, in the early afternoon, differed from measurements in the morning and in the late afternoon, but there was no systematic or one-way shift in direction of orientation. The mean early afternoon HEADING (Fig. 4 A2) was significantly more southerly than earlier and later in the day ($F_{am} = 17.43$; $p < 0.001$; $F_{pm} = 11.81$; $p < 0.001$) (Fig. 4 A1 and A3), but the mean early afternoon BEARING (Fig. 4 B2) differed in the opposite direction by being significantly more westerly than earlier in the day ($F_{am} = 6.9$; $p < 0.01$) though it did not differ from the same measure later in the day ($F = 1.59$; $p > 0.05$) (Fig. 4 B1 and B3). Differences in wind between sampling periods did not account for the variation in flight directions.

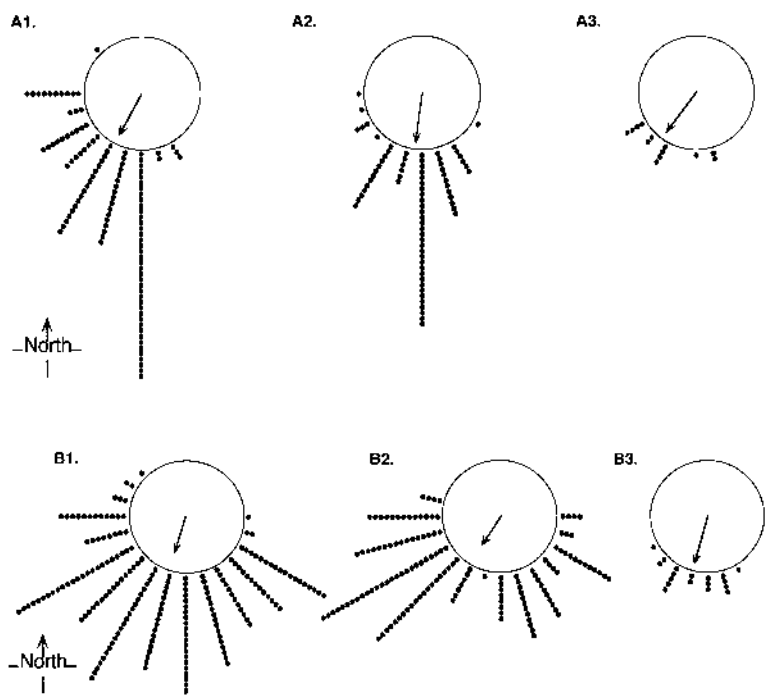

Figure 4. (A) HEADING and (B) BEARING data and resultant vectors for individuals observed during three time periods: (1) morning (09:00–10:30), (2) early afternoon (13:00–14:30) and (3) late afternoon (15:15–16:30). Each circle represents one migrant.

Discussion

This study demonstrates that monarch butterflies in North America use sun compass orientation during their southward fall migration. While flying through open fields in Kansas, USA, migratory butterflies orient their bodies in a SSW direction (200–220º). By experimentally resetting migrants' circadian rhythms in the lab, we caused them to misinterpret the sun's position and to shift their direction of orientation. These findings would result only if the butterflies had been orienting their bodies using the time of day and the position of the sun (i.e., a sun compass). The significance of this discovery is that we have identified a major orientation mechanism that the butterflies can use to find their distant winter roost sites. Thus, the monarch butterfly joins the small group of vertebrate and arthropod species for which a sun compass orientation mechanism has been experimentally demonstrated.

Monarchs use a sun compass to orient their flight but do not fly directly toward the sun as suggested by Kanz (1977). This statement is supported by the fact that the direction the monarchs fly in the morning is not different from the direction they fly in the late afternoon, although the position of the sun is significantly different at these two times. Moreover, although mean HEADINGs and BEARINGs varied throughout the day, there was no systematic, one-way change in orientation direction in the course of a day and, therefore, no suggestion that the migrants are simply flying toward the sun. We do not yet know whether monarch butterflies, like ants (Santschi 1923) and bees (Frisch 1967), make simultaneous use of polarized light (Wehner et al. 1996b) for orientation in the field, although there is strong indication that they can use polarized light in the lab (Hyatt 1993).

In this study, HEADING data were more easily interpreted than BEARING data because they were more robust to the effect of cross-winds. Where BEARING data gave a measure of the animal behavior plus the environmental effect of the wind, HEADING data gave us a measure of the animals' behavior alone. Because natural control results indicate close agreement between the two measures in the absence of a chilling treatment, we relied on HEADINGs alone to demonstrate that migrating monarchs can discern which direction they should fly. Although it was the HEADINGs rather than the BEARINGs which gave us the best insights into the butterflies' "intentions," the end result of migration is not the butterfly's intended direction of movement (HEADING), but instead its actual direction of movement (BEARING). The suite of traits under selective pressure includes both the individual's ability to determine where to go, as well as its ability to get there. These two abilities, therefore, should comprise the focus of future monarch migration studies. We suggest that that two fruitful areas of study in monarch orientation will be: 1) determining the butterflies' intentional "surfing" use of large scale winds (Walker & Riordan 1981; Walker 1985), and 2) finding alternative mechanisms of orientation, such as a geomagnetic compass (Baker & Mather 1982; Baker 1987; Jones & MacFadden 1982; MacFadden & Jones 1985; Wiltschko & Wiltschko 1996), that the butterflies can use on overcast days when they need non-celestial directional cues.

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Mark and recapture during the monarch migration: A preliminary analysis

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Abstract

Monarch butterflies were recently demonstrated to use the sun for orientation during the autumn migration; however, the monarch's ability to respond to their geographic location has remained unclear. In this study, we analyzed mark-recapture data collected in monarch tagging programs over a period of 40 years to determine whether monarchs have a geographic sense. Mean flight directions were analyzed based on geographic location and net flight distance. We found that the mean direction of flight shifts S to SW as the origin of flight moves west to east and possibly as the origin of flight moves north to south. As flight distance increases, the mean direction of flight also shifts S to SW and the scatter of the flight directions decreases. This shift in flight direction and reduction of data scatter indicates that monarchs experience SE drift over shorter distances, but ultimately compensate for this drift by re-orienting according to their new position. Thus, monarchs are shown to orient differentially according to their location, strongly suggesting the use of a geographic locational sense during migratory flight.

Introduction

Each autumn, the eastern North American population of monarch butterflies, *Danaus plexippus* (L.), migrate south-southwest from summer breeding grounds in the eastern United States and Canada to overwintering sites in the Transvolcanic Mountains of central Mexico (Urquhart 1976; Brower 1996). The ability of migrants to find their way between breeding and non-breeding locations over long distances implies the use of both a compass, allowing orientation in a given direction, and a geographic sense, providing information about geographic location (Kerlinger 1995). A recent study established the monarch's use of a sun compass for orientation (Perez et al. 1997 and this volume), but the means of navigation, course setting and possible course correction, has not yet been demonstrated. Here, we show that monarchs orient differently depending on longitude and perhaps latitude, and that monarchs ultimately compensate for SE drift by re-orienting according to their new position. These results strongly suggest the existence of a general geographic locational sense in migratory monarchs.

In this study, we analyze mark-recapture data collected in monarch tagging programs over a period of 40 years. Mean flight directions are analyzed, based on geography and net flight distance.

Methods

Mark-recapture data were compiled from three sources (Urquhart 1960; Urquhart and Urquhart 1964–1994; Taylor 1993–1997). We only used records with clear origins and recovery points. None of the records involve reared butterflies or those that had been transferred from one region to another. Three components were defined for each tag recovery: flight vector (net direction of flight), latitude-longitude of the origin of flight, and net flight distance. Flights of at least 16 km, originating from 30–50ºN latitude and 70–100ºW longitude during August, September, or October were analyzed. The data were grouped into one of three longitudinal regions (69º 59´–79º 59´W, 80º–89º59´W, and 90º–100ºW) and one of three latitudinal regions (30º–36º 39´N, 36º40´–43º 19´N, and 43º 20´–50ºN) based on the origin of flight; they were placed into one of three flight distance groups (16–630 km, 631–1,260 km, and 1,261–3,650 km); and the long-distance group was subdivided into two groups based on whether or not recapture occurred at the overwintering sites (south of 20°N latitude). Because a relatively large subset of the flights originated from the vicinity of Toronto, Ontario (43º40´N, 79º25´W), we compared flights originating from within 1º latitude and 1º longitude of Toronto to all flights originating from the eastern longitudeinal region.

Results

The mean flight direction for all migrants (N = 519) is 195º 48´, with a concentration of directions in the SW and SE quadrants (Figure 1). Comparison of mean flight among longitudinal regions indicates that as the origin of flight moves W to E, the mean direction of flight shifts S to SW (Figure 2). Differences between the mean directions are significant ($p < 0.05$) from the west to central regions and the west to east regions, but not from the central to east regions (Tables 1). Comparison of mean flight directions among latitudinal regions suggests there is a S to SW shift in flight directions as the origin of flight moves N to S (Figure 3). However, these differences are not significant (Table 1); this is perhaps attributable to the low number of observations in the most southern region.

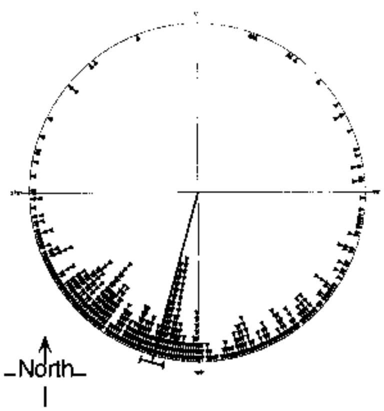


Figure 1. Vectors of monarch flights originating from 30–50ºN latitude and 70–100ºW longitude (μ = 195.8º; r = 0.74; n = 519). A Raleigh test of uniformity showed that the mean flight vector differs significantly from random ($p < 0.05$).

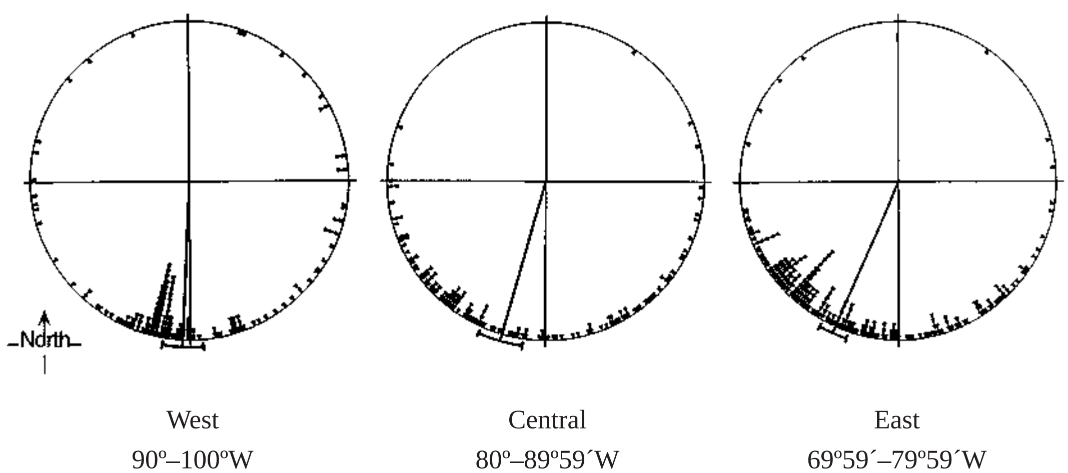
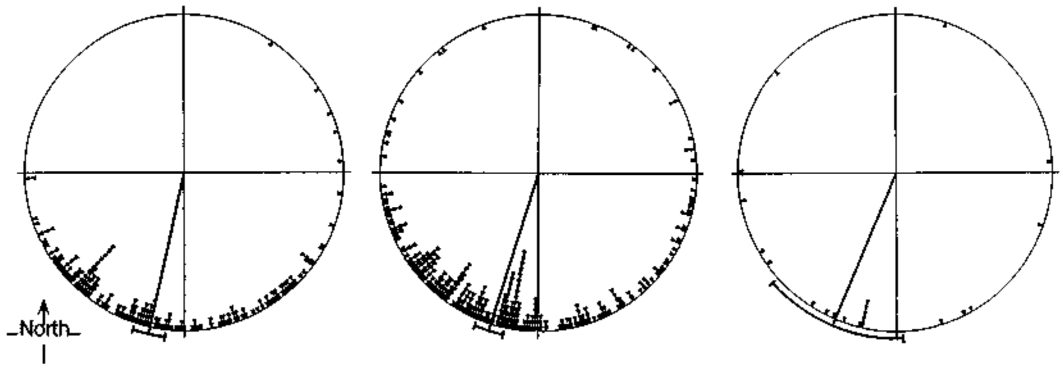


Figure 2. Vectors of monarch flights originating from 90–100ºW longitude (μ = 182º54´; r = 0.72; n = 158), 80º–89º59´W longitude (μ = 195º42´; r = 0.71; n = 134) and 69º59´–79º59´W longitude (μ = 204º; r = 0.78; n = 227). Raleigh tests of uniformity showed that mean flight vectors differ significantly from random in each region ($p < 0.05$).



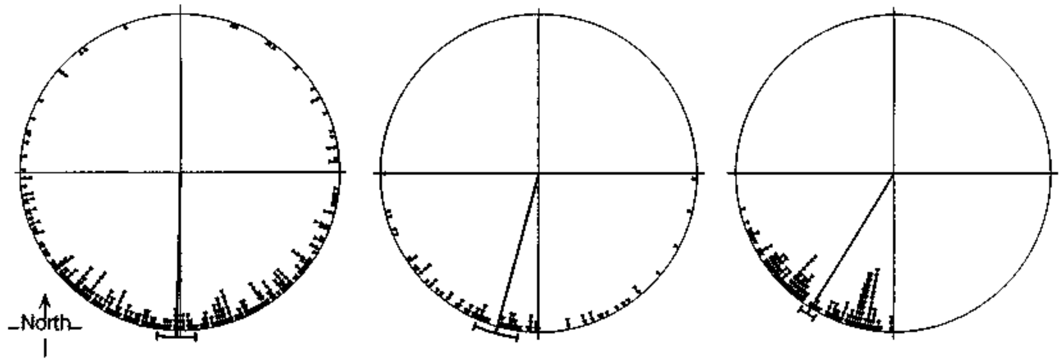
North 43º20´–50ºN | Central 36º40´–43º19´N | South 30º–36º39´N

Figure 3. Vectors of monarch flights originating from 43º20´–50ºN latitude ($\mu = 192º42´$; $r = 0.78$; $n = 189$), 36º40´–43º19´N latitude ($\mu = 197º24´$; $r = 0.72$; $n = 308$), and 30º–36º39´N latitude ($\mu = 203º12´$; $r = 0.59$; $n = 22$). Raleigh tests of uniformity showed that mean flight vectors differ significantly from random in each region ($p < 0.05$).

Table 1 Differences between the mean directions of flight
F-test values for all analyses

Analysis	Samples	F	p
Longitude	West and Central	4.50	0.03
	Central and East	2.61	0.11
	West and East	18.98	0.00
Latitude	North and Central	1.18	0.28
	Central and South	0.26	0.61
	North and South	0.83	0.36
Flight Distance	Short and Medium	4.04	0.05
	Medium and Long	22.15	0.00
	Short and Long	45.77	0.00
Toronto	Toronto Vicinity and East Region	3.05	0.08
Overwintering Site Recaptures	Recaptures at Roosts and Recaptures North of Roosts	25.63	0.00

As the flight distance increases, the mean direction of flight shifts S to SW (Figure 4). Differences between the mean directions are significant ($p < 0.05$) for short to long distances and medium to long distances, and are marginally significant ($p = 0.05$) for short to medium distances (Table 1). The scatter of the flight directions also decreases with increasing flight distance; scatter is reduced to the two southern quadrants in the medium-distance flights, and is reduced to the SW quadrant in the long-distance flights (Figure 4).



Short Distance
16–630 km

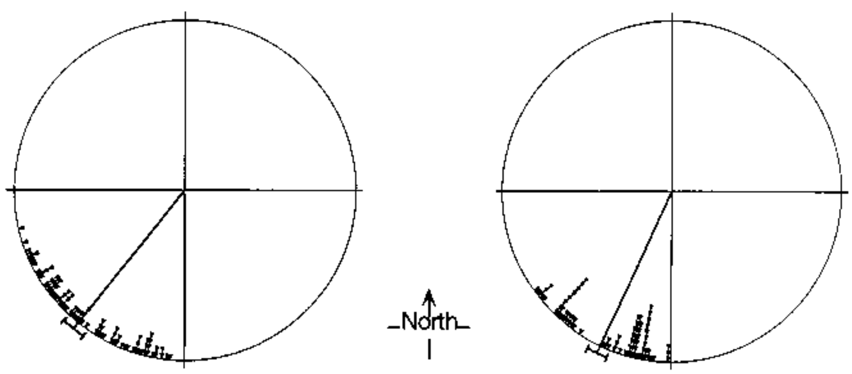
Medium Distance
631–1,260 km

Long Distance
1,261–3,650 km

Figure 4. Vectors of monarch flights of 16–630 km, ($\mu = 181º24´$; $r = 0.63$; $n = 278$), 631–1,260 km ($\mu = 195º12´$; $r = 0.84$; $n = 76$), and 1,261–3,650 km ($\mu = 212º6´$; $r = 0.95$; $n = 165$). Raleigh tests of uniformity showed that mean flight vectors differ significantly from random in each flight distance group ($p < 0.05$).

The comparison of flights originating from the vicinity of Toronto ($N = 63$) and from the eastern longitudinal region ($N = 133$) showed no significant difference ($p > 0.05$) between the mean directions (Table 1).

The mean flight direction of monarchs recaptured at the overwintering sites is significantly ($p < 0.05$) more S than that of other long distance migrants (Table 1, Figure 5). Of the monarchs recaptured at the overwintering sites, none originated from longitudes between 85º 04´W and 89º 58´W, resulting in the appearance of bimodality for these data.



Recovered North of Overwintering Sites
North of 20ºN

Recovered at Overwintering Sites
South of 20ºN

Figure 5. Mean vectors of monarchs recovered south of 20ºN latitude ($\mu = 204º48´$; $r = 0.96$; $n = 79$) and north of 20ºN latitude ($\mu = 218º54´$; $r = 0.95$; $n = 86$). Raleigh tests of uniformity showed that mean flight vectors differ significantly from random in each sample ($p < 0.05$).

Conclusions

This study shows that monarchs orient differently depending on longitude and perhaps latitude. Differential orientation according to location suggests that monarchs can interpret their approximate position relative to the overwintering sites, and thus likely use a geographic locational sense in conjunction with compass mechanisms during migratory flight.

The S to SW shift in flight directions as the origin of flight moves west to east (Figure 2) indicates that monarchs respond to their relative longitude and orient toward the overwintering sites accordingly. Although the data do not show a significant shift in flight directions as the origin of flight moves north to south, the pattern of SW shift (Figure 3) suggests that monarchs may also respond to their relative latitude. Alternatively, this shift could occur as a function of time or distance traveled, or could be a response to proximate factors in the southeast such as the predominately east winds along the Gulf coast.

The S to SW shift in flight directions and the decrease in the directions' scatter as flight distance increases (Figure 4) indicates that over shorter distances, monarchs experience SE drift, but ultimately compensate for this drift over longer distances. This compensation could result from the monarchs orienting according to their relative longitude and/or latitude, even as their position changes.

In addition to the SE drift represented by the recoveries in this study, several lines of evidence suggest that migratory monarchs experience considerable displacement to the SE. Observations by Gibo (1986) in southern Ontario indicated that migratory monarchs drifted S-SE under conditions of W, NW, or N winds. The overall predominance of these winds in eastern North America during the fall and monarchs' limited ability to overcome crosswinds due to slow flight speeds (Gibo 1986) suggests that almost all monarchs must experience some SE drift during the migration. This is also supported by a growing number of observations suggesting that migratory monarchs utilize N and NW tailwinds along weather fronts (Taylor 1993–1997; Brower 1996; Gibo, unpublished data). In order to arrive at the overwintering sites, located SW of the breeding locations, monarchs must eventually change their orientation to compensate for any significant SE displacement. This suggests a migratory flight strategy by which monarchs first utilize the predominate NW winds, despite deviation from the most direct course, and then, when the wind speed and direction are more favorable, compensate for this deviation by re-orienting according to their new relative position.

That monarchs from the vicinity of Toronto fly in the same general direction as monarchs from the entire eastern longitudinal region indicates that: (1) the mean directions for a longitudinal region are generally valid for specific locations within the region, and (2) monarchs interpret their position on a broad, not specific, scale.

The difference in mean flight directions between monarchs recaptured at the overwintering sites and those recaptured at more northern locations (Figure 5) indicates that after the monarchs cross into Mexico, their relative direction changes back from the SW to the S. Although this effect too may indicate a response to latitude and longitude, other observations of the migratory flight in Mexico (Calvert and Wagner, this volume) imply that the monarch's flight patterns through this region may be determined by proximate factors such as topography and the availability of nectar sources.

When directions from mark-recapture data are compared to measurements of migratory headings, it is important to bear in mind that mark-recapture data provide more information about long-distance patterns, but unlike headings, they provide little information about short-distance flights and the conditions under which flight occurs (Brower 1996). However, despite the differences between these two types of data, we found that our results were generally consistent with those derived from heading data (Schmidt-Koenig 1979, 1993; Perez et al. 1997).

Although this study strongly suggests that monarchs utilize a geographic locational sense, perhaps based on the earth's magnetic field (Schmidt-Koenig 1993), the mechanism for their response to location is still unknown. We suggest that future monarch migration studies focus on the basis for interpreting relative position and its relationship to orientation mechanisms.

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The lethal plant defense paradox and the influence of milkweed latex on larval feeding behavior of the monarch butterfly

by ***Stephen B. Malcolm***, ***Myron P. Zalucki***, ***Barbara J. Cockrell*** and ***Baldwin J.A.A. Mwakamela***

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Abstract

The monarch butterfly is perhaps the best known example of warning coloration based on the use of plant-derived chemical defenses by an insect herbivore against natural enemies. Adult monarchs are conspicuously colored orange and black as an aposematic warning signal to bird predators that they are poisonous because they sequester toxic cardenolides from the milkweed host plants of their larvae. Moreover, monarchs have been shown to vary in the amounts of their chemical defense according to the species of milkweed used by their larvae. Thus monarchs from milkweeds with low cardenolide tend to be poorly defended, whereas those from milkweeds with high cardenolide content appear to be well defended against bird predators. These results suggest that monarchs are adapted specialists that handle host-derived defenses effectively. This poses a paradox for milkweeds that invest in cardenolide defenses against herbivores because the more cardenolide that a plant synthesizes, the greater the apparent defense benefit to the monarch, which could in turn lead to increased larval feeding. However, our recent research has shown that plants may be able to resolve this paradox because milkweed cardenolides are inducible by larval feeding and together with a latex delivery system this has a negative impact on early instar monarch larvae. Here we describe results of experimental manipulations of larval feeding behavior in response to milkweed latex and discuss their implications for the evolution and ecology of milkweed-monarch interactions within the context of the lethal plant defense paradox.

Introduction

Larvae of the monarch butterfly, *Danaus plexippus* (L.), are specialist herbivores of milkweeds in the family Asclepiadaceae. This bright orange and black butterfly is well known both because it is conspicuous and because it sequesters toxic steroids, known as cardenolides, from its larval host plants (Brower 1969; Brower & Glazier 1975; Malcolm 1991, 1995). These cardenolides are used by adult monarchs as the distasteful and toxic basis of their aposematism, advertised by conspicuous, warning coloration.

Cardenolides are a good example of one of the two basic chemical tactics that plants are thought to use in their defenses against herbivores. Optimal defense theory (McKey 1974; Rhoades & Cates 1976; Rhoades 1979), apparency theory (Feeny 1976, 1992) and resource availability theory (Janzen 1974; McKey et al. 1978; Bryant et al. 1983; Coley et al. 1985) are all based on a similar argument to explain the presence in plants of both small, acutely toxic chemical molecules, such as cardenolides, and large, chronically effective molecules, such as tannins (Herms & Mattson 1992). These basic molecular differences have been described respectively, as qualitative versus quantitative chemical defenses (Feeny 1976), toxins versus digestibility reducers (Rhoades & Cates 1976), mobile versus immobile chemical defenses (Coley et al. 1985), or lethal *versus* sublethal chemical defenses (Clancy & Price 1987).

Price et al. (1980) were the first to point out the paradox associated with sublethal, digestibility-reducing defenses that result in increased leaf consumption by herbivores. They showed that this *sublethal plant defense paradox* (Figure 1) was resolvable by natural enemies in the third trophic level because slow-growing insect herbivores were more vulnerable to predation, and the presence of predators resulted in a net decrease in leaf tissue loss due to herbivory (Thompson 1982; Orr & Boethel 1986; Clancy & Price 1987; Barbosa 1988).

The second paradox has been called the *"lethal" plant defense paradox* by Malcolm (1995) and Malcolm and Zalucki (1996) because, although small plant toxins may kill non-adapted herbivores, such as generalist species with broad diets (Figure 1), most insect herbivores are specialists (Bernays 1988, 1989; Bernays & Graham 1988), and many of these specialists store, or sequester, host plant-derived toxins and use them for their own chemical defenses against natural enemies at the third trophic level (Rothschild 1973; Duffey 1980; Smiley et al. 1985; Denno et al. 1990; Malcolm 1991; Rowell-Rahier & Pasteels 1992). Thus greater investment in toxic chemical defenses by a plant may lead to enhanced fitness of specialist herbivores and result in reduced plant fitness. In contrast to "sublethal" defenses, the *"lethal" plant defense paradox* operates between herbivore and natural enemy trophic levels (Figure 1) and we have been investigating whether plants can resolve this paradox.

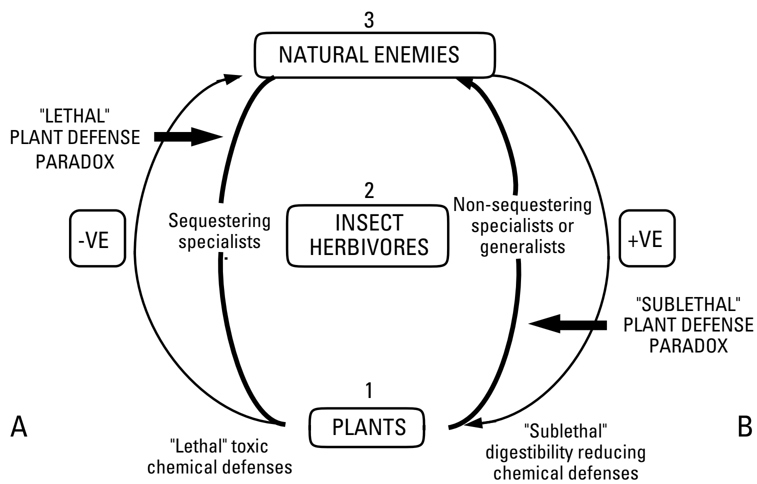

Figure 1. Three trophic level interactions among plants, insect herbivores and natural enemies generate two plant defense paradoxes based on their investment in either toxic or digestibility-reducing chemical defenses.

A. ***The "Lethal" Plant Defense Paradox:*** Toxins can have an acute, lethal effect on generalist herbivores but many specialists sequester and use toxins as a defense against their own natural enemies (negative indirect influence by plants on herbivore natural enemies). Thus "lethal" plant defenses pose a paradox at the third trophic level because high investment in toxic, qualitative chemical defenses by a plant can enhance the fitness of herbivores when natural enemies are present and paradoxically reduce plant fitness.

B. ***The "Sublethal" Plant Defense Paradox:*** Digestibility-reducers have chronic or sublethal effects on herbivores and can prolong the development of herbivores without killing them. This leads to increased plant consumption and reduced fitness despite the higher investment in chemical defense. The paradox is resolved at the third trophic level because slower growing herbivores are more vulnerable to natural enemies than faster growing herbivores on control plants (positive indirect influence by natural enemies on plants).

In our research we chose the cardenolide-mediated interaction between the common milkweed and the monarch butterfly because *D. plexippus* is known to sequester cardenolides more effectively from *A. syriaca* than from any of the other 11 similarly studied milkweed species, even though *A. syriaca* has a low constitutive cardenolide content (Malcolm & Brower 1989; Malcolm et al. 1989; Malcolm 1991). Moreover, *A. syriaca* provides the largest and most widespread biomass of exploitable larval food resources for migratory monarchs in North America (Malcolm et al. 1992, 1993) because it is the most abundant and widespread milkweed species and its geographical distribution coincides with that of summer breeding monarchs (Woodson 1954; Malcolm et al. 1989; Malcolm & Brower 1989; Malcolm et al. 1993). Although *A. syriaca* has low constitutive cardenolide concentrations, it has a high latex content in comparison with other common species in North America (Malcolm et al. 1989; Malcolm 1991, 1995) and it can induce cardenolides rapidly in response to leaf damage (Malcolm and Zalucki 1996). Malcolm (1995) and Malcolm and Zalucki (1996) suggested that *A. syriaca* has reduced investment in constitutive cardenolide defenses, but that it is able to compensate through rapid induction of cardenolides in response to leaf damage by herbivores. The process has interesting implications for the dynamics of the interaction between *A. syriaca* and monarches because induction may help to resolve the paradox of a plant investing in chemical defenses that benefit sequestering specialist herbivores.

Monarchs were thought to be adapted specialists that incur little cost to feeding as larvae on milkweeds and appear to benefit both nutritionally and defensively from their milkweed diet (Malcolm 1991, 1995). However, recent evidence has shown that the larvae are negatively affected by the milky latex characteristic of milkweeds (Zalucki et al. 1990; Zalucki & Brower 1992; Malcolm & Zalucki 1996; Zalucki & Malcolm 1998) and Zalucki et al. (1990) found that early instar larval mortality increased significantly with increasing cardenolide in the milkweed, *A. humistrata*. Moreover, monarch larvae deploy vein cutting and trenching behaviors to circumvent leaf latex defenses (Dussourd & Eisner 1987; Zalucki & Brower 1992; Dussourd 1993), which suggests that latex and perhaps cardenolides present problems for foraging larvae. Cardenolides in *A. syriaca* also appear to have no effect on tachinid parasitoids of monarch larvae (Hunter et al. 1996). Together, these results suggest that monarch larvae are vulnerable to some natural enemies and that milkweeds may be able affect larval mortality and resolve the lethal plant defense paradox, either directly or indirectly, with the help of natural enemies.

Malcolm and Zalucki (1996) and Zalucki and Malcolm (1998) found that monarch larvae feeding on leaves of the common milkweed, *A. syriaca* L., grow faster on leaves that have been manipulated by partially severing the petiole to mimic natural larval feeding behavior and reduce latex flow in the leaf. Although it is clear that leaf latex has a negative impact on larval growth, it is not known whether this is a behavioral or physiological/toxicological response to latex and its mechanical and chemical effects. Thus we investigated the effect of milkweed latex on larval performance with observations of first instar larval foraging behavior and consequent larval growth in response to either normal latex in intact leaves or experimentally reduced latex in leaves with partially severed petioles. We hypothesized that increased larval growth rate on partially severed leaves should be the result of increased time spent feeding instead of avoiding latex. We predicted that the reduced latex content of partially severed leaves should increase larval time spent feeding and increase growth rates in comparison with larvae on intact leaves. To test these hypotheses, we compared the feeding behaviors and growth performance of first instar larvae on intact and partially severed leaves.

Methods

During July 1997, adult female monarch butterflies were collected from the field at Arcadia Commons in Kalamazoo, Michigan, U.S.A. Mated females were placed in screen cages with potted plants of the milkweeds *Asclepias curassavica*, *A. incarnata* or *A. syriaca* under fluorescent lights in a laboratory, fed sucrose solution and left to lay eggs. Eggs were collected each morning by cutting them from leaves with a hole punch (5mm diameter). Each leaf disc, with its egg, was placed on water-moistened filter paper in a Petri dish and kept at room temperature of 26ºC. At the black-head developmental stage, shortly before larval emergence, eggs were placed in a cold cabinet at 5ºC to stop development and synchronize larval emergence from collected eggs using day-degree accumulation (Zalucki 1982). Eggs that were about to hatch were transported to the field in Petri dishes on ice in a cooler chest.

Larval foraging behaviors were observed in the field on stems of *A. syriaca* in the Goldsworth Valley of the Western Michigan University campus in Kalamazoo, Michigan, USA. *A. syriaca* is a highly modular milkweed and the perennial genetic individual, or genet, grows from rhizome-like roots that produce many closely-spaced, unbranched ramets or stems with large, opposite leaves. Adjacent, nearest-neighbor ramets within the same *A. syriaca* genet were chosen for each paired observation of intact and partially-severed treatments. Ten separate genets of *A. syriaca* were used as the 10 replicates for each treatment. Intact, control treatments and partially severed treatments were compared with paired t-tests because they were paired on adjacent ramets within the same genet.

The mean heights for partially severed ramets and intact, control ramets were 77.3 cm and 73.7 cm respectively. Ramets also had a mean number of leaf pairs of 10.4 for partially severed treatments and 9.7 for intact treatments. Leaves of partially severed treatment ramets had a mean length of 14.8 cm and a mean width of 6.5 cm. Leaves of intact ramets had a mean length of 13.9 cm and a mean width of 5.6 cm. None of these measures differed significantly between partially severed ramets (N = 10) and intact ramets (N = 10), among the 10 genets.

Paired *A. syriaca* stems were selected and randomly assigned to intact or partially severed treatments. On the partially severed stem, all leaves above the third leaf pair (from the plant top) were partially severed by clipping a 5 mm section of each petiole three times with a pair of toothed forceps. One egg that was about to hatch was glued with a dab of latex from a nearby *A. syriaca* leaf to the underside of the third leaf from the top of both the intact and partially severed stems and left to hatch. All behaviors of the newly emerged larvae were observed and recorded for the first two hours. Each larva was then enclosed in a 13 mm diameter clip cage to restrain and protect them from predators during the periods they were not being observed. The experimental observations of each larva were then repeated during daylight hours for two hourly periods, separated by a break of two hours, until the larva molted to the second instar stage. A total of 10 larvae were observed on intact leaves and 10 larvae on partially severed leaves. At the end of the experiment, second instar larvae were collected, placed on ice and returned to the laboratory where they were weighed. All leaves with observed feeding damage were collected in the field and placed on ice and returned to the laboratory, where they were digitized to measure total and consumed leaf areas.

Results

Larval foraging behavior

During a total of 256.6 hours of field observations, we observed monarch larvae engaging in seven basic behaviors on *A. syriaca* leaves. These behaviors included eating the egg shell (25% of larvae), spinning a pad of silk from which a larva could dangle when disturbed (100% of larvae), grazing hairs on the underside of a leaf (90% of larvae), chewing a leaf either partially, or all the way through the lamina (100% of larvae), avoiding latex with various avoidance behaviors (such as rearing the head, moving to the side or dropping on a silk thread) (95% of larvae), moving (90% of larvae), and resting (100% of larvae).

Immediately after emerging from its egg, a larva either ate its eggshell, or rested, and then spun a pad of silk. Larvae often grazed leaf hairs from the safety of their silk pads, or moved to another part of the leaf and spun silk and grazed leaf hairs. Once hairs were grazed from an area, the larvae would then chew through the epidermal cells into the lamina. If larvae managed to avoid leaf laticifers and the latex contained within them, they would continue to feed in the same place. However, 19 out of 20 larvae chewed into laticifers and suddenly released large amounts of milky-white latex. Latex often stuck to the mouths or heads of larvae, and upon contact with latex, they would rapidly back away, then move their heads from side-to-side and rub their head capsules against the leaf surface. Larvae would then usually repeat the behaviors associated with biting, spinning and resting, until holes were chewed through the leaf blade. These holes often resulted in C-shaped trenches with abundant latex on the outer perimeter of the C and little latex on the leaf material inside the C-shaped hole. After successfully cutting off latex flow to the leaf material left inside the C-shaped trench, most larvae spent time chewing at this small, circular portion of the leaf. This behavior is likely to result in reduced contact with latex, especially on intact leaves.

Larvae spent most of their time resting and chewing with 57.2% and 50.5% of the time spent resting by larvae on intact and severed leaves, respectively, and 22.7% and 29.2% of their time chewing intact and severed leaves, respectively. Most of the foraging behaviors showed no significant difference between larvae observed on intact or partially severed leaves (Table 1). There were no significant differences between the proportion of time that larvae spent resting ($t_9 = 1.39$; $P = 0.20$), spinning ($t_9 = 1.20$, $P = 0.26$), moving ($t_7 = 0.09$; $P = 0.93$), grazing hair ($t_7 = 1.56$, $P = 0.16$), or avoiding latex ($t_8 = 0.81$; $P = 0.44$, Table 1). Only 5 out of 20 larvae ate their egg shells (2 intact and 3 severed) and so there were insufficient data for a comparison. However, larvae did spend a significantly higher proportion of their time chewing the leaf blade of partially-severed leaves than intact leaves ($t_9 = 2.22$; $P = 0.05$; Table 1). There were also trends towards larvae spending proportionately more time resting and spinning on intact leaves than on partially severed leaves (Table 1), but these differences were not significant at the 5% level of confidence.

Table 1 Proportions of time engaged in 7 behaviors by first monarch larvae on intact and partially severed leaves

Behavior	Treatment	Mean	SE	N	t-value	P	significance
Resting	Intact	0.572	0.048	10	1.39	0.20	NS
	Severed	0.505	0.025	10			
Chewing leaf	Intact	0.227	0.029	10	2.22	0.05	–[a]
	Severed	0.292	0.013	10			
Spinning	Intact	0.072	0.009	10	1.20	0.26	NS
	Severed	0.055	0.009	10			
Moving	Intact	0.070	0.018	9	0.09	0.93	NS
	Severed	0.067	0.013	9			
Grazing hair	Intact	0.044	0.015	8	1.56	0.16	NS
	Severed	0.056	0.015	10			
Eating egg	Intact	0.028	0.027	2	–	–	–[b]
	Severed	0.021	0.006	3			
Avoiding latex	Intact	0.027	0.007	9	0.81	0.44	NS
	Severed	0.024	0.007	10			

Note: Paired t-tests of proportions of time (arcsine square root transformed) engaged in 7 behaviors by first instar monarch larvae on intact (N = 10) and partially severed (N = 10) leaves of the milkweed *Asclepias syriaca,* based on 256.6 hours of field observations on 20 larvae in Michigan during July & August 1997. Sample sizes for individual behaviors vary because not all larvae showed every behavior. Behaviors are ranked according to intact mean proportions.

[a] Significant at a = 0.05.

[b] Insufficient data for comparison.

Leaf area eaten

Larvae showed a trend towards more leaf area eaten on partially severed leaves (28.4 mm^2) than on intact leaves (21.8 mm^2) of *A. syriaca,* and at a faster rate on partially severed leaves (8.9 mm^2/day) than on intact leaves (6.1 mm^2/day)(Table 2). However, paired t-tests failed to detect significant differences between intact and partially severed leaves for both leaf area eaten ($t_9 = 1.72$; $P = 0.12$; Table 2a) and rate of leaf area eaten per day ($t_9 = 2.09$; $P = 0.07$; Table 2b).

Table 2a — **Leaf area eaten (mm^2)**

Treatment	Mean area	SE	N	t-value	P	Significance
Intact	21.8	5.8	10	1.72	0.12	NS
Severed	28.4	4.8	10			

Note: Paired t-tests of leaf areas eaten (mm^2) by first instar monarch larvae on intact or partially severed leaves of *A. syriaca.*

Table 2b — **Leaf area eaten/day (mm^2/day)**

Treatment	Mean area/day	SE	N	t-value	P	Significance
Intact	6.1	1.3	10	2.09	0.07	NS
Severed	8.9	1.5	10			

Note: Paired t-tests of leaf areas eaten per day (mm^2/day) by first instar monarch larvae on intact or partially severed leaves of *A. syriaca.*

Table 2c — **Correlations between larval foraging behaviors (proportions) and leaf area eaten per day (mm^2/day)**

	Intact		Severed	
Behavior	correlation	P	correlation	P
Eating egg	–[a]	–	–	–
Spinning	0.29	0.43	0.34	0.35
Grazing hair	0.79	0.02[b]	0.003	0.99
Chewing leaf	0.71	0.02[b]	-0.36	0.31
Avoiding latex	0.26	0.51	0.43	0.23
Moving	-0.46	0.22	0.64	0.07
Resting	-0.69	0.03[b]	-0.39	0.28

[a] Insufficient data for correlation.
[b] Significant at $P<0.05$.

Correlation analyses between larval foraging behaviors and leaf area eaten per day (mm^2/day) showed both positive and negative correlations (Table 2c). Grazing hair and chewing the leaf blade were both positively correlated with leaf area eaten per day on intact leaves, whereas resting was negatively correlated. On partially severed leaves, only moving was marginally correlated with leaf area eaten per day (at $P = 0.07$).

Larval weights

Both larval weights (mg) and mean growth rates per day (mg/day observed, assuming equal weights at the start of the experiment) suggest that larvae fed on partially severed leaves grew larger and faster than larvae on intact leaves (Table 3). However, paired t-tests for both larval weights ($t_9 = 0.78$; $P = 0.45$; Table 3a) and larval growth rate per day ($t_9 = 0.69$; $P = 0.52$; Table 3b) showed no significant differences between first instar larvae on intact and partially severed leaves.

Table 3a — **Larval weights (mg)**

Treatment	Weight	SE	N	t-value	P	Significance
Intact	2.27	0.39	10	0.78	0.45	NS
Severed	2.64	0.20	10			

Note: Paired t-tests of larval weights (mg) of first instar monarch larvae on intact or partially severed leaves of *A. syriaca.*

Table 3b — **Larval growth rates (mg/day)**

Treatment	Mean growth	SE	N	F-value	P	Significance
Intact	0.74	0.15	10	0.69	0.52	NS
Severed	0.85	0.09	10			

Note: Paired t-tests of larval growth rates (mg/day) of first instar monarch larvae on intact or partially severed leaves of *A. syriaca.*

Table 3c — **Correlations between larval foraging behaviors (proportions) and larval weight (mg) increment per day (mg/day)**

	Intact		Severed	
Behavior	correlation	P	correlation	P
Eating egg	–[a]	–	–	–
Spinning	-0.10	0.80	-0.71	0.02[b]
Grazing hair	0.59	0.13	-0.46	0.19
Chewing leaf	0.24	0.51	0.07	0.83
Avoiding latex	0.14	0.73	-0.45	0.19
Moving	-0.09	0.83	-0.03	0.94
Resting	-0.39	0.28	0.77	0.01[c]

[a] Insufficient data for correlation.
[b] Significant at $P<0.05$.
[c] Significant at $P<0.01$.

Correlation analyses between larval foraging behaviors and larval growth rates (mg/day) showed both positive and negative correlations (Table 3C). None of the correlations on intact leaves were significant, but on partially severed leaves, spinning was significantly negatively correlated with larval growth rate ($P = 0.02$), and resting was significantly positively correlated with larval growth rate ($P = 0.01$).

Discussion

There was a general trend for both foraging behaviors and growth performance by first instar larvae of the monarch butterfly, *Danaus plexippus*, to increase with a decrease in leaf latex caused by partial severing of leaf petioles. Larvae spent significantly more time chewing the leaf blade on partially severed leaves than on intact leaves. Also, there were trends towards spending more time resting and spinning by larvae on intact leaves than on partially severed leaves, which may reflect the risk associated with encountering leaf latex during feeding. However, the remaining behaviors observed did not differ significantly between larvae feeding on intact or partially severed leaves.As in previous studies (Zalucki et al. 1990; Zalucki & Brower 1992; Malcolm 1995; Malcolm & Zalucki 1996; Zalucki & Malcolm, 1998), first instar larvae were faced with the problem of dealing with both the mechanical stickiness of latex and toxic cardenolides present in the latex of *A. syriaca* (Malcolm et al. 1989), yet unlike these earlier studies, we found only a weak influence on larval growth. There seem to be three possible explanations for this result. First, the partial-severing technique applied to leaf petioles may not have been sufficiently severe to reduce latex flow to a level that significantly influenced larval growth, despite a trend towards the expected increase in larval growth on partially severed leaves when compared with larvae on intact leaves. Second, the C-shaped trench cut by observed larvae may reduce contact with latex and reduce the impact of experimental latex reduction on larval growth. Thus, larvae on the intact leaves may have decreased the latex flow themselves to a level comparable to that in the manipulated leaves. This may have influenced the significant increase in chewing time on partially severed leaves, but it did not translate into a significant negative impact on larval growth. Third, larvae in the manipulated plants may have used latex-avoiding behaviors even in the absence of latex, or in reduced latex presence. First instar monarch larvae may have fixed feeding behaviors to deal with plant defense and in these experiments showed little response to experimental variation in leaf latex. Monarch butterflies typically show highest mortality during the first instar (Zalucki & Brower 1992) and we expected that newly hatched larvae would be forced to spend less time feeding on leaf tissue and more time avoiding latex on intact leaves than on partially severed leaves. Although larvae did spend significantly more time chewing partially severed leaves, they did not spend more time avoiding latex, or spinning silk, or resting on intact leaves than on partially severed leaves, as we expected.

From these experiments, we cannot distinguish between the possibility that first instar monarch larvae are little affected by latex on intact and partially severed leaves because they grow equally well, or equally poorly. This suggests that monarch larvae, by their foraging behavior, either fit their literature portrayal as well-adapted specialists that benefit from milkweed investment in chemical defenses, or that they are in fact suffering considerable costs from handling latex and other chemical defenses, such as cardenolides and all the other secondary metabolites known to occur in *A. syriaca* (Malcolm et al. 1989; Malcolm 1991). In addition, we are unable to distinguish whether our results are due to a toxic effect of leaf latex, or a mechanical effect. Leaf latex may act as a defense through its mechanical stickiness and rapid coagulation on small, chewing herbivores. Zalucki and Brower (1992) found that latex outflow from damaged leaves of *A. humistrata* was rapid, followed by coagulation on contact with air. Although we found many naturally-occurring larvae mired with latex, we did not actually observe any become trapped in coagulated latex during the timed observations. Monarch larvae were adept both at avoiding latex and circumventing latex flow by isolating leaf tissue from the latex source (see also Dussourd & Eisner 1987; Dussourd & Denno 1991; Dussourd 1993). This was done by cutting small leaf veins and chewing to form a circular "island" within a C-shaped trench. If latex did contact larval mouthparts or head regions, larvae first raised their heads and then cleaned away the latex by rubbing the mired areas against the leaf surface. First instar larvae are inexperienced at avoiding latex and occasionally could not avoid ingesting it. After involuntary ingestion of latex, larvae were traumatized and they did not resume eating for prolonged periods of time. Nevertheless, we were unable to show clearly the behavioral mechanism by which larvae show increased performance on leaves with disrupted latex flow.

We are currently investigating the influence of cardenolide induction, coupled with latex delivery, on the foraging, growth, and mortality performance of larval monarchs feeding on the common milkweed, *A. syriaca*, for two reasons. First, we want to know whether the plant can solve the lethal plant defense paradox by using dynamic chemical defenses (latex + cardenolides). We think that the combination of latex and inducible cardenolides poses problems for first instar larvae, but not for later instars. The plant may resolve the paradox by reducing cardenolide and latex back to or below constitutive levels with time so that older larvae have less access to the cardenolides they sequester for defense. Second, we want to know whether monarch larvae really are adapted specialists that incur little cost to feeding on milkweeds and only reap benefits from cardenolide sequestration and their aposematic lifestyle. However, as the results of this paper and our other work suggests, monarch larval performance appears to be constrained by both latex and inducible cardenolides in milkweed leaves. The next step is to find out how the dynamics of plant defense influence sequestration by the monarch butterfly and what influence this might have on monarch defense against their natural enemies.

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Estimating the effect of climate on the distribution and abundance of *Danaus plexippus*: A tale of two continents

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Abstract
We estimate the effect of climate on the distribution and relative abundance of monarchs in Australia and North America. We use the location and season of collection from the labels of museum specimens in Australia, or the known limits of the species' range, as the base data on which to draw inferences using the CLIMEX analysis package, a computer program for matching climates. CLIMEX can be used to describe the relative growth and persistence of a species in relation to climate. From experimental observations and the inferred responses of monarchs to temperature and moisture in Australia, we predict the species' changing seasonal distribution in North America and its potential global distribution. We also predict changes in relative abundance among years due to variable climatic conditions, and changes in geographic distribution due to climate change. Models such as these will be crucial to the interpretation of changes in monarch abundance if we wish to disentangle the effects of various factors, such as changes in overwintering sites and host plant abundance, from the normal variation due to climate alone.

Introduction
Population ecologists are generally interested in explaining patterns of abundance and distribution of the species they study. As is generally recognized, where a species is found and how many occur at any one time are not constant. Rather, abundance and distribution are dynamic, changing at varying rates over time and space (Hengeveld 1990). Many theories have been proposed to account for this variation, and these can be broadly divided into two groups: those that view climate, either directly or indirectly through its interactions with species-specific characters, as the major determining factor (Andrewartha & Birch 1954, Walter & Zalucki 1998); and those that view multi-species interactions such as competition and predation as being paramount (Pimm 1991).

The debate among the various schools has engendered more heat than light, for two reasons. First, the approach of both tends to be descriptive; each attempts to account for patterns in data, either statistically or by using models derived from theory. Rarely does either school attempt to test predictions by direct experiment. Secondly, the schism between the two schools is based on a fundamental difference of interpretation of how evolution proceeds. If species-species interactions are paramount in species' abundance and distribution, then evolution is localized, incremental and continuous. Species characters will be predicted to be labile and variable throughout a species' range. If climate is paramount, then species characters are stable with long periods of stasis; species will track the distribution of suitable habitat through time and space or go extinct when these deteriorate, or they evolve locally in isolation thus leading to occasional jumps in speciation (Paterson 1993, Walter & Zalucki 1998).

It is possible to make predictions of where a species may be found and in what relative abundance, and at least partially test them, and so shed some light on the influence of climate and other factors on species abundance and distribution. Any species that has a wide and variable distribution will suffice. Species that have been either accidentally or deliberately introduced to new geographic areas, and have established and spread, fit this description. We use the monarch butterfly, *Danaus plexippus* L., to illustrate the approach and to briefly explore long term changes in abundance at one location. We also address the question of what may happen to monarchs given certain climate change scenarios. We first describe the effect of climate variables on the species' range in one geographic region (Australia). We then use that description to predict its abundance and distribution in other regions (North America). Concordance between the predicted and observed distributions can be used to indicate that climate may well account for the species range. Discrepancies indicate that other factors need to be included, or that our model is not appropriate.

Estimating the effects of climate on where animals are found

Physiologists have long been aware of the effects of extreme variation of climatic variables, such as temperature and moisture (variously measured), on essential physiological processes (e.g., thermoregulation, osmoregulation and growth), and of the consequences of such extremes for the development, survival and reproduction of organisms. Such work is useful in delineating the potential geographic range, based on the effect of extremes on the most sensitive stages (Liebig's Law of the minimum, see e.g., Krebs 1985). Rarely has work on the physiology of animals been translated to its population consequences, partly because of the vast amount of experimental work required for realistic interpretations. One would need to measure the variation in response in say survival, reproduction or development among many individuals with differing experience under many combinations of environmental conditions. Nevertheless, findings by physiologists provide many clues as to the effect of climate on populations (e.g., Kingsolver 1989).

Non-physiologists have used various approaches to estimate the ecological consequences of climate. Climograms (two dimensional plots of climate variables against each other) have been used to infer possible suitable sites, based on similarity to known good sites. In a variation on this approach, Rogers (1979) estimated mortality rates due to climate from an analysis of a long series of abundance data for Tsetse fly, *Glossina* sp. He plotted in climate space where reproduction exceeded mortality and so mapped a species' potential distribution. Various multivariate statistical techniques have been used to infer, from distributional data, the climatic factors that most likely account for the species' range. These approaches essentially determine the "climate envelope," a set of usually arbitrary meteorological values, that encompasses the locations where a species currently exists, or was known to exist from collection records. However, the meteorological variables chosen tend to be arbitrary, and not necessarily related to biological processes that in fact determine abundance and distribution. In addition they may have arbitrary temporal resolution, e.g., temperature in the hottest month, range of temperature in the coldest quartile and so forth. As many collection records will be from sites without meteorological recording stations, the various methods usually rely on interpolated climate surfaces.

A number of methods for fitting climate envelopes are available. These methods vary in both the climate variables used and the way in which envelopes are defined. Some use standard statistical techniques, such as generalised linear modelling (Nichols 1989). Others use computer programs that incorporate specialised algorithms. Such programs include HABITAT (Walker & Cocks 1991), BIOCLIM (Busby 1991) and DOMAIN (Carpenter et al. 1993). Some methods (e.g., generalised linear modelling and HABITAT) can incorporate variables such as soil type and vegetation type, in addition to climate variables, when defining "envelopes."

We use a different approach: a hybrid that considers both the physiological effects of climate on processes affecting populations, and the known spatial distribution of a species. We infer the climatic requirements of a species from its known distribution using the CLIMEX package (Maywald and Sutherst 1991). CLIMEX has been used extensively in biological control programs and pest risk analysis to predict potential distributions of Diptera (Sutherst et al. 1989), Hymenoptera (Spradbery & Maywald 1992), Coleoptera (Heard & Forno 1996), Homoptera (Hughes & Maywald 1990) plants (McFadyen & Skarratt 1996), and a vertebrate (Sutherst et al. 1995).

In its standard form, CLIMEX assumes that individuals at a given location experience two seasons during a year, one favorable to population increase, and the other unfavorable to the species survival or persistence. A growth index (GI), analogous to population growth rate, describes the potential of the population to increase at a location during the favourable period. The growth index, scaled between 0 and 1, is calculated weekly, and is a product of temperature (TI) and moisture indices (MI), viz:

$$GI = TI * MI.$$

For both the TI and MI indices, there is a range of conditions of temperature and moisture over which growth is maximal. On either side of the optimum range growth decreases. Above some upper threshold and below a lower threshold growth ceases.

Persistence at a location is modelled by four stress indices (SI), describing the species response to extreme cold (CS), heat (HS), dry (DS) and wet (WS) conditions, and, if needed, their interactions (SX)—cold-dry (CDS), cold-wet (CWS), hot-dry (HDS) and hot-wet (HWS) stresses. The stress indices (SI) are accumulated at some rate whenever conditions exceed a specified threshold.

A measure of the relative suitability of a location is summarized in a single annual eco-climatic index, EI, scaled to 100, viz: $EI = 100 \sum GI/52 * SI * SX$, where 52 is the number of weeks in a year.

Indices are calculated on a weekly basis for each location using standard meteorological information. A location's long term monthly average maximum and minimum temperatures, rainfall, and humidity values are used as inputs to calculations of the various indices. Areas with positive values for EI are suitable for a species, and the larger the value of EI, the more suitable the location. The values for parameters that describe the TI and MI components of growth, and the various stress indices (SI), and their interactions (SX) can be estimated from laboratory or field studies. Unknown or poorly measured values are estimated by an iterative procedure that involves comparing the predicted distribution with the observed. The results of such parameter tuning can be validated by comparing the predicted and observed species distribution in an area not used for the procedure.

We made one change to the above procedure. We arbitrarily divided the year into four periods (Sept–Nov, Dec–Feb, Mar–May and Jun–Aug) corresponding to the four seasons. We calculated the EI for each period using the one set of parameters. We reasoned that for species that are highly mobile, the distribution will shift seasonally to areas where climate is more suitable. We compare the predicted and observed seasonal distributions of monarchs in Australia, and predict seasonal distributions in North America (below).

Monarch distribution

Ackery and Vane-Wright (1984) recorded the distribution of *D. plexippus plexippus* and its very close, and difficult to distinguish, relative *D. plexippus erippus* (Fig. 1). The monarch greatly extended its range around the middle of the 19th century to encompass most of the south Pacific Islands, although both the means (Vane-Wright 1993) and timing (Kitching et al. 1993) of this range expansion have been debated (Brower 1995). Maps showing the monarch's seasonal distribution in North America have differed greatly over the years, particularly in relation to overwintering range, summer breeding in the south-eastern USA, and overlap between eastern and western populations. In North America the monarch has two well defined populations (Fig 1), one in the east of the continent and one in the west. The very large panmictic eastern population spends the winter at a few well defined sites in Mexico, remigrating back into the southern USA in spring. The offspring of the spring migrants then move into the northeastern USA and southern Canada, not extending much further north than 50º (Cockrell et al. 1993, Malcolm et al. 1993). Monarchs are absent from the southeastern USA in summer; see Malcolm et al. (1987) for Florida, Riley (1993) and Lynch and Martin (1993) for Louisiana and Texas, and Urquhart (1960) for Alabama. In southern Florida a small subpopulation breeds year round (Malcolm and Brower 1986). A smaller western population with numerous small "overwintering" sites occurs along the US west coast and has a less well defined movement pattern, exploiting numerous milkweed species growing in specific habitats, in areas with steep altitudinal gradients. Overwintering populations break up in mid- to late winter, exploiting coastal milkweed patches, whereas in some favourable coastal locations monarchs continue to breed throughout the year, spreading inland in summer (Wenner & Harris 1993). The inland boundaries of these two populations are not well defined. Most of the eastern population is east of about 97º W, and the western population peters out somewhere in the Rocky Mountains.

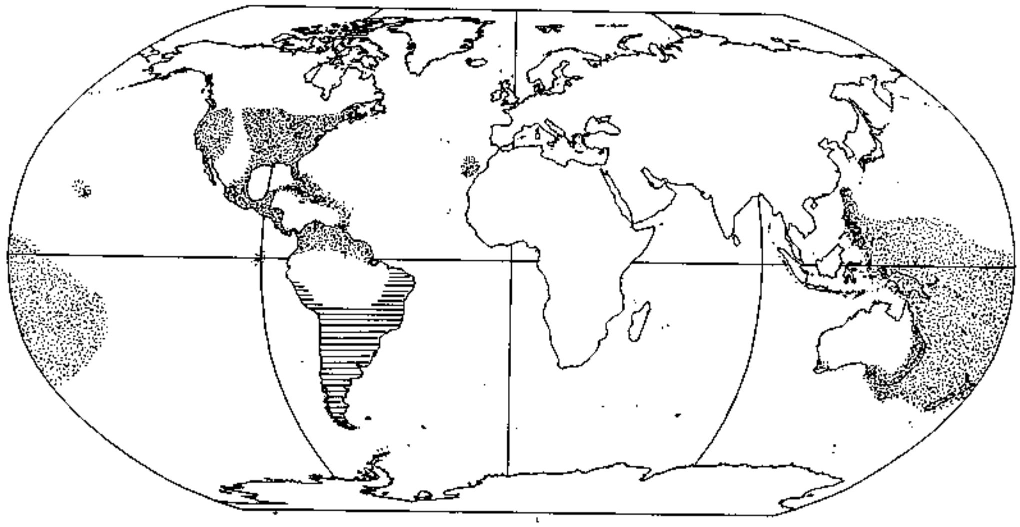

Figure 1. World wide distribution (stippled) of the monarch butterfly, *Danaus plexippus*. The distribution in southern South America (horizontal hatching) is for *D. p. erippus* (see Ackery & Vane-Wright 1984). For Australia see Zalucki (1986), and Fig 2.

Monarchs in Australia were "first" recorded around 1870 and spread rapidly throughout the continent (Vane-Wright 1993). Based on label data of 1,519 specimens from various museums and private collections, and the literature (see Acknowledgments and Dunn & Dunn 1991), there is a reasonably clear-cut seasonal distribution (Fig. 2). In Australia there is a close relative—the lesser wanderer, *Danaus chrysippus*—that is also taken by collectors. We have plotted the location records for 679 specimens of this species (Fig. 2). The absence of monarchs from certain locations and at certain times can be taken as real, and not an artefact due to lack of collecting effort, as *D. chrysippus* was collected in these locations. This overcomes a major limitation of many distribution studies, namely that negative record sites are not often reported.

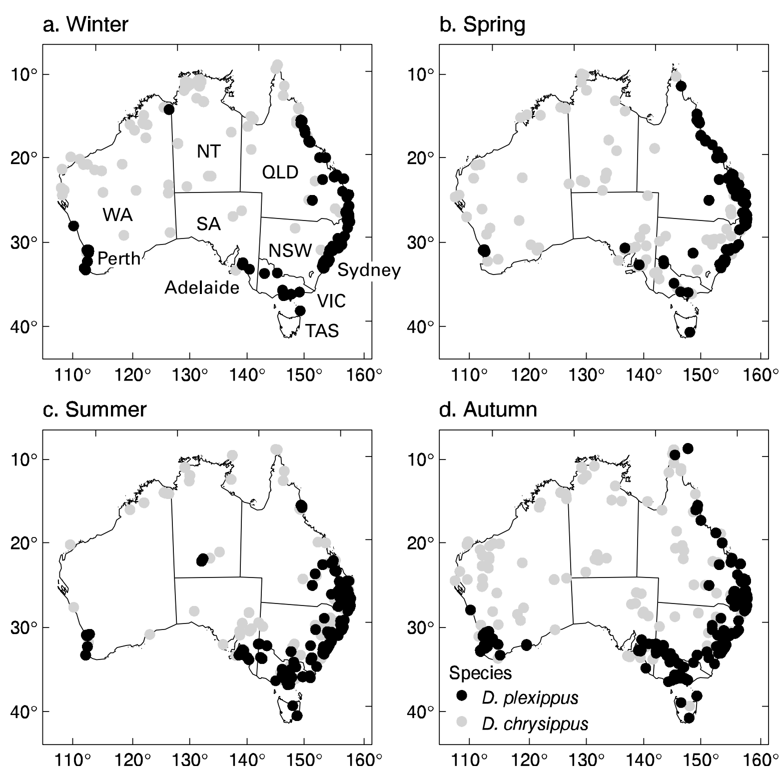

Figure 2. The seasonal distribution of *Danaus plexippus* in Australia for (a) winter, (b) spring, (c) summer and (d) autumn. Also shown is the seasonal distribution of *D. chrysippus*. The information comes from label data of specimens in museums, private collections and the literature (see Acknowledgments).

Populations of monarchs breed year round from around Sydney north along the Queensland coast (James 1993, Zalucki 1993). Monarchs expand to a summer range (Fig. 2) incorporating Victoria, Tasmania (occasionally), and inland New South Wales and Queensland. In autumn, adults move back into coastal areas, overwintering in clusters side by side with a breeding population in the Sydney area (James 1993). They are believed to overwinter in the Adelaide Hills area (Fig. 2) and a population persists in southwest Western Australia (Fig. 2), although there are few studies in these areas.

Relevant biology of monarchs

Masters (1993) reviewed the effects of temperature on aspects of the biology and ecology of monarchs. Immatures develop between about 12ºC and 31ºC (Rawlins & Lederhouse 1981, Zalucki 1982), requiring about 350 degree days (DD), above a developmental threshold of 11.5ºC, to develop from egg to adult, about 400 DD to the beginning of egg laying, and a further 150 DD to peak egg-laying (Zalucki 1981). Survival of immatures declines below 10ºC (they are not known to be able to survive prolonged periods with frosts), and declines above 33–35ºC (Zalucki 1982, Malcolm et al. 1987). Adults fly readily between 12ºC and 41ºC (Masters et al. 1988), and temperatures above 41ºC are lethal (Masters 1993). Overwintering adults can survive down to lower temperatures (-14ºC) than their summer counterparts (-1.5ºC) (Anderson & Brower 1993). Thus it is the immature stages that are likely to be more sensitive to temperature changes. In recent experiments in California, we found that eggs and first instars failed to survive when air temperatures exceeded 37ºC for 2 days (Zalucki & Paine, unpublished).

Based on limited data, Zalucki (1981) found that egg development in adults had a similar lower threshold temperature (11–12ºC) to immature development. Barker and Herman (1976) found ovarian development in the range 20–28ºC, declining above 35ºC, with no or little development around 15ºC. James (1993) found adults failed to reproduce if they experienced about 10 days below 18ºC.

The effects of dry and wet conditions on development, survival and reproduction are not well studied. Adults do not oviposit on wet overcast days, but will compensate for some of the shortfall in egg-laying on the next available fine day (Zalucki 1981).

For phytophagus insects the availability of suitable host plants will greatly influence their distribution and abundance. Monarchs oviposit on milkweeds (Asclepiadacea) and almost exclusively on plants in the genus *Asclepias* (Malcolm & Brower 1986). Milkweeds are generally cold intolerant and die back quickly in areas where frosts occur. Depending on the species of milkweed that grows in a particular area, there will be other climatic conditions (e.g., moisture) and edaphic factors that may also limit their distribution and abundance. Thus it is possible that an area may be suitable climatically for monarchs but not for milkweeds, and vice versa.

The fitted distribution in Australia

The final set of CLIMEX parameters (Table 1) were inferred from field and laboratory information, or were estimated iteratively by adjusting values until the CLIMEX-predicted seasonal distribution in Australia matched the observed records (compare Fig. 2 and Fig. 3). One set of values produces a seasonally changing distribution that agrees well with observation and suggests that the same processes are operating on the species regardless of season. The southern and inland parts of the species' range become unsuitable for monarchs in winter, and the species contracts to coastal areas in the east, and to around Adelaide in South Australia and south-western Western Australia. Certainly, milkweeds will be scarce in the areas monarchs have vacated, as the plants are frost sensitive and die back in winter. Patches of plants persist only in warmer coastal areas.

Table 1	CLIMEX parameter values giving the best visual fit to the distribution of *Danaus plexippus* in Australia each season	
Parameter and its description	**Value**	**Source**
Moisture*		
Lower threshold (SM0)	0.10	Fitted
Lower limit of optimal range (SM1)	0.50	Fitted
Upper limit of optimal range (SM2)1	.50	Fitted
Upper threshold (SM3)	2.5	Fitted
Temperature (ºC)		
Lower threshold (T0)	11.5	Zalucki 1982
Lower limit of optimal range (T1)	26	see text
Upper limit of optimal temperature (T2)	29	Zalucki 1981, 1982
Upper threshold (T3)	35	Zalucki 1982
Stress Indices		
Soil moisture dry stress (SmDs)	0.40	Fitted
Weekly accumulation of dry stress	0.001	Fitted
Soil moisture wet stress (SmWs)	2.0	Fitted
Weekly accumulation of wet stress	0.0005	Fitted
Threshold of cold stress (TCs)	6.0	Zalucki 1982
Weekly accumulation of cold stress	0.005	Fitted
Threshold of heat stress (Ths)	31	Zalucki 1982
Weekly accumulation	0.00125	Fitted

* Moisture parameters are in units of proportion of soil moisture holding capacity

From spring to autumn, Tasmania should be suitable for monarch populations (Fig. 3b,c,d). However, they are not frequently recorded in Tasmania (less than 1% of all records). Either milkweed is not common in Tasmania or few adults journey across Bass Strait. Winter is not a suitable period in Tasmania and the species is unlikely to persist (Fig. 3a). The prediction for northern Australia, that monarchs shift north in autumn and spring (Fig. 3bd) and south again in the summer, and are less abundant in the winter (Fig. 3), reflects the tropical heat of northern Australian summers, and the relatively dry winters, even in coastal areas. The limiting factors in inland areas in summer are a combination of heat and dry stress (plots not shown). Using the current set of parameters, monarchs should not persist in the summer around Perth and Adelaide (Fig. 3c). By adding irrigation (reflecting the use of sprinklers in suburban gardens where milk-weeds are grown) monarchs can persist in these areas, agreeing with the limitation being due to dry stress.

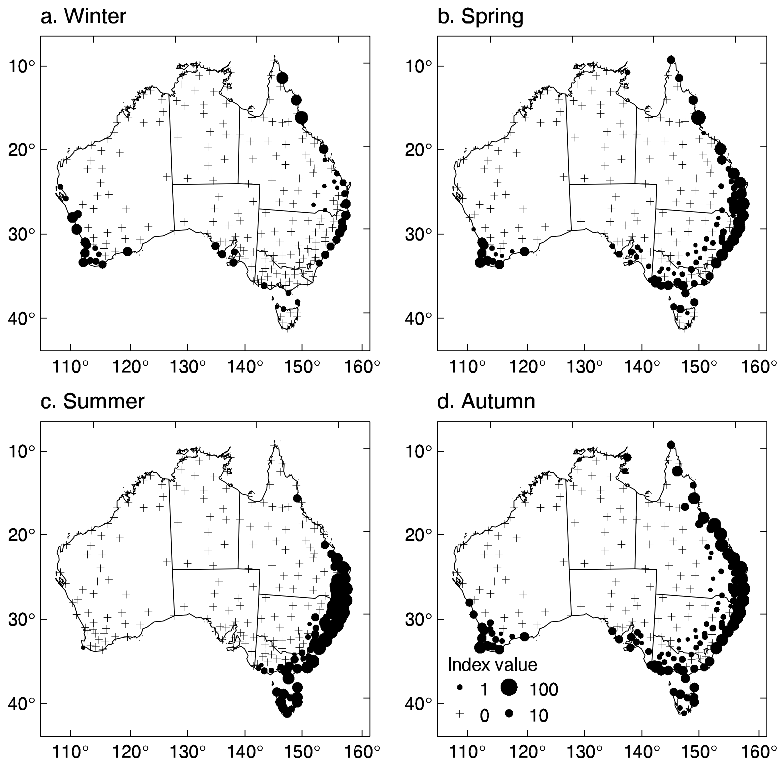

Figure 3. The fitted seasonal distribution of monarchs in Australia as measured by the ecoclimatic index using CLIMEX parameters in Table 1 for (a) winter, (b) spring, (c) summer, and (d) autumn. The suitability of climate at each location is proportion to area of the circle. Locations marked with a cross have indices of zero.

Predictions for North America

Using the same set of parameters as derived for Australia (Table 1) we predict the seasonal distribution in North America (Fig. 4). No attempt has been made to fine tune the parameters for North America. The winter distribution suggests that some localities in coastal California may be suitable for breeding, as may be the coastal Gulf of Mexico area as well as southern Florida (Fig. 4a). Monarchs do breed through the winter in coastal California (above), as well as southern Florida (above). Populations should persist in parts of Mexico year-round also (Fig. 4). CLIMEX uses average climatic conditions in its meteorological data base to determine its various indices. These will not reflect the extreme climatic conditions that can occur from time to time at any location. Thus New Orleans experiences infrequent, but severe winters with absolute minima down to -13.9ºC (Muller 1982). No monarch life stage will persist long under these conditions, not even cold tolerant adults if conditions are damp (Anderson and Brower 1993), nor will milkweed persist in areas with frosts. We would therefore not expect monarchs to persist along the Gulf coast. In spring (March–May, Fig. 4b), the south-eastern USA becomes suitable, as does southern California. The northern limit of spring breeding agrees with the observations of Malcolm et al. (1993) on the dynamics of spring recolonization. By summer (June–Aug, Fig. 4c), the northern part of the monarch's range is re-established, and the south vacated, as has generally been observed (above). The limitation for monarchs beyond ca 50ºN is the time required to successfully complete development. Locations not providing the 500 DD minimum to complete a generation have been excluded (Fig. 4c). This northern limit coincides with the approximate northern limit of milkweed. Few sites in Australia have such a limitation for development of monarch generations, except in the southern Australian Alps and parts of Tasmania. Monarchs disappear from southern California due to dry stress. No doubt populations will persist in well-watered areas. The lack of suitable sites for breeding populations in the western USA is perhaps more a reflection of the paucity of sites whose climatic data are included in CLIMEX. This part of the USA has high topographic relief and steep environmental gradients. Locations for breeding are likely to shift with altitude through the season. We would need to use interpolated climate surfaces to more accurately predict seasonal monarch distribution.

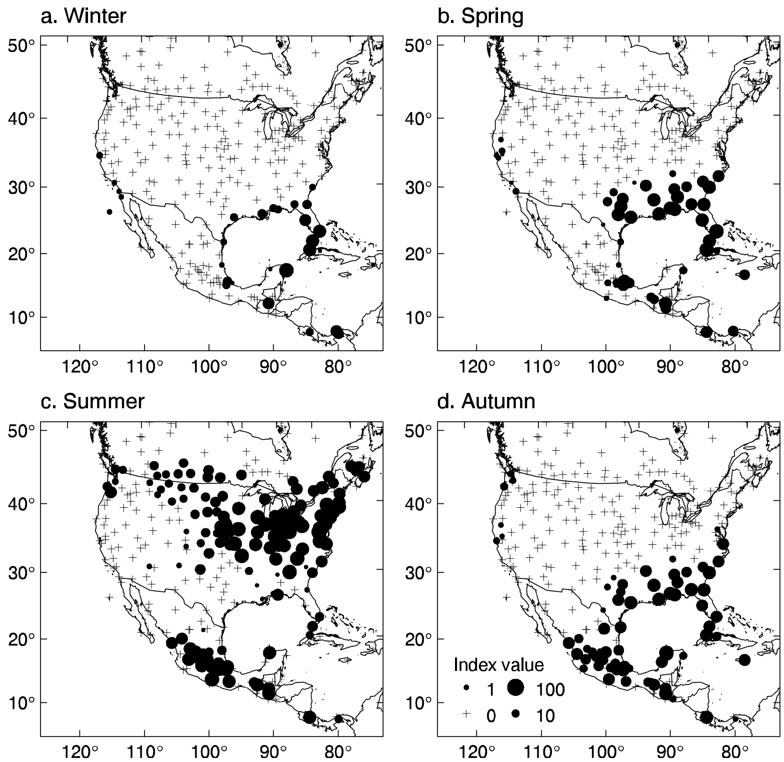

Figure 4. The predicted distribution of monarchs in North America using CLIMEX parameters in Table 1 for (a) winter, (b) spring, (c) summer and (d) autumn. For summer we include the limitation of a site providing a minimum 500 degree days above 11.5ºC to complete a generation. Locations marked with a cross have indices of zero.

We have not included adult diapause in our CLIMEX model, so the autumn distribution (Fig. 4d) predicted for eastern USA is unrealistic, as these butterflies will be in diapause and moving down into Mexico, although our prediction is that any non-diapause adults in this part of the southern USA could breed if milkweed were available.

Further predictions and discussion

That a simple set of parameters fitted to one area gives such a reasonable account of the monarch's seasonal distributions elsewhere suggests that similar processes and responses to climatic variables underlie their ecology. We use the same set of CLIMEX parameters (Table 1) to project the potential world-wide distribution of monarchs (Fig. 5). This prediction encompasses known distributions (Fig. 1), including that of *D. p. erippus* in South America and the Pacific. Other areas, such as central and southern Africa, western Europe, and parts of Asia, also appear suitable. Either the monarch has not yet been introduced to these areas, or the number arriving has been too few to establish, or other limiting factors, such as an absence of milkweed, may prevent successful establishment.

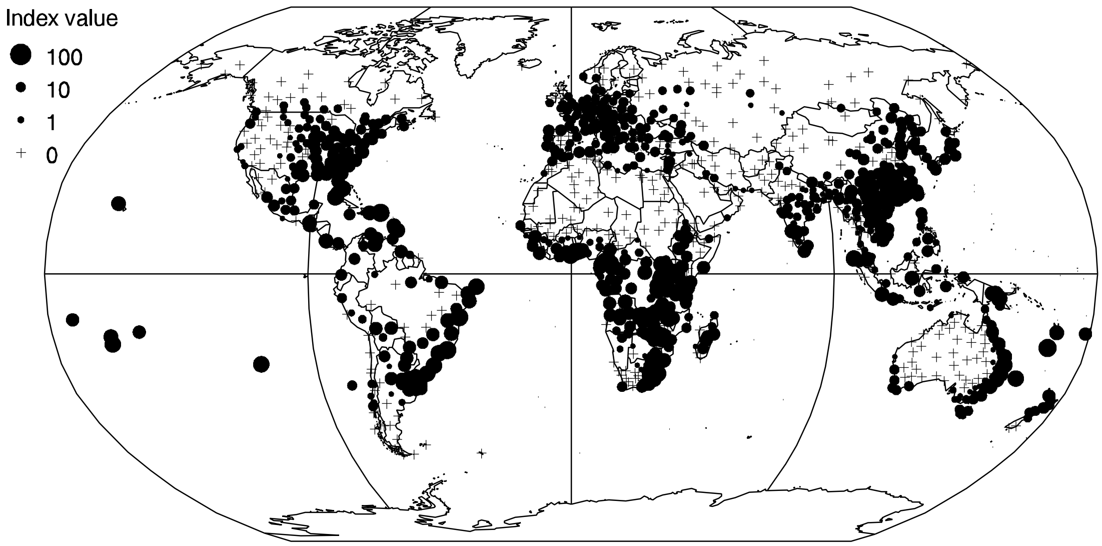

Figure 5. The predicted world-wide distribution of monarchs. Each positive point is an average of suitable EI values (see text for details) over four seasons. Locations marked with a cross have indices of zero.

Apart from seasonal variation in climatic condition, there are also natural long-term changes in climate that greatly affect the distribution of species (Hengeveld 1990). More recently there has been great interest in climate change or the greenhouse effect, brought about by human activities, on the distribution of species (e.g., Walker & Steffen 1996). The climate change scenario for North America (Fig. 6) is based on a 0.1ºC rise in summer and winter maximum and minimum temperatures per degree of latitude, and a 20% increase in rainfall in summer, and a 20% decrease in winter rainfall. The likelihood of persistence of monarchs through the winter in the gulf states should increase (Fig. 6a), as has breeding throughout the winter in California. Persistence of overwintering clusters in California in a state of diapause may be less likely. What would happen in Mexican overwintering sites, given their greater altitude, is not clear, but should be considered as a matter of urgency in any conservation strategy. The suitable spring range is much larger (Fig. 6b), and the monarch would extend much further north into Canada, even with the 500 DD limitation on development, assuming milkweeds also extend their range, in the summer (Fig. 6c). This would mean a larger distance to move back to Mexico in the fall. If milkweed cannot extend onto the Canadian Shield due to edaphic factors, then monarch summer range in the eastern USA will narrow. Monarchs would disappear from a much wider area of the southern USA in summer, and would find it difficult to persist around southern Florida in the summer also (Fig. 6c). Only time will determine if these predictions are borne out.

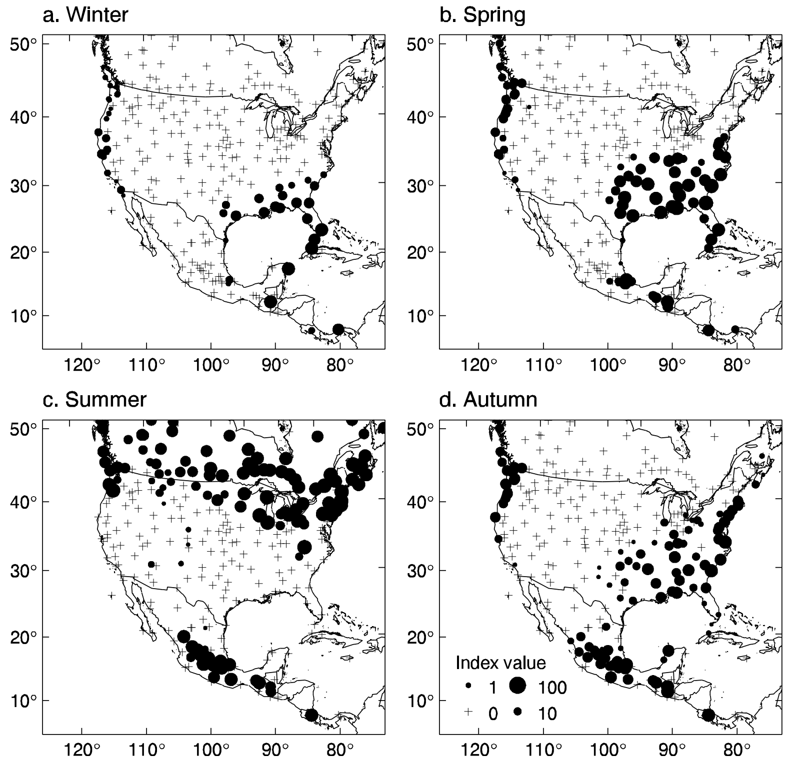

Figure 6. The predicted change in monarch distribution in North America for (a) winter, (b) spring, (c) summer and (d) autumn, given a climate change scenario of a 0.1ºC rise in summer and winter maximum and minimum temperatures per degree of latitude, and a 20% increase in rainfall in summer, and a 20% decrease in winter. Locations marked with a cross have indices of zero.

To illustrate the changing suitability of climate for population increase over years, we simulate the Ecoclimatic Index, EI, for Amberley (lat 27º 38´ long 152º 43´), a site within the core range of monarchs in Australia (in south east Queensland, Fig. 2), using 20 years of climatic data. Monarchs are predicted to fluctuate widely in abundance here. Seasonally, the species is expected to build up from a low during winter to peak in summer, which agrees with field observations (Zalucki & Kitching 1984, Zalucki et al. 1993). Winters had an average EI value of 4, with 41% of years as low as zero; spring values average 23 (with 9% of years having a zero value), summer EI's were around 30 (9% zero), and autumn EI's were around 26 (9% zero). Among years, abundance can vary by up to 500%; from a low during 1965, a very dry year (EI = 6), to a high in 1983 (a comparatively wet year with EI = 30). The basic point we make with this analysis is that, when interpreting changing abundance of a species, we have to first take into account the influence of climate on its potential abundance. Deviations from this prediction can then be used as evidence that further factors need to be considered. Thus, apparent declines in some years should not immediately be attributed to factors such as herbicide treatment of milkweeds, or apparent deterioration of overwintering sites, as has been speculated for North America. They may simply reflect normal variation in abundance, due to normal climatic variation, from year to year.

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Host migration and the prevalence of the protozoan parasite, *Ophryocystis elektroscirrha*, in natural populations of adult monarch butterflies

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Abstract

Monarch butterflies are susceptible to infection by the obligate protozoan parasite, *Ophryocystis elektroscirrha*. Because monarchs form both resident and migratory populations in different parts of the world, this host-parasite system provides the opportunity to explore the association between disease prevalence and host movement patterns. We examined samples from 14,790 adult monarchs captured in North America and other areas between 1968 and 1997. Comparison of three populations in North America indicates that disease prevalence is associated negatively with the magnitude of host dispersal. A continuously breeding population in southern Florida shows high disease prevalence (over 70% heavily-infected), whereas the migratory population in western North America has intermediate prevalence (30% heavily-infected). The eastern migratory population, which travels the longest distance, has exhibited less than 8% infection with this parasite throughout the past 30 years. We investigated within-population variation in parasite prevalence in North American monarch butterfly adults to determine whether prevalence was associated with time during the yearly migratory cycle and migration distance. For monarchs captured breeding throughout western North America, average spore loads and prevalence of heavy-infection decreased with increasing distance from overwintering sites. This observation suggests that heavily-infected adults are less likely to remigrate to distant breeding locations in the spring. However, no patterns in the frequency of heavily-infected adults were found among eastern migratory monarchs during breeding, migrating, and overwintering periods. Differences in parasite prevalence among Australian monarchs suggest that climatic variation, in addition to host breeding ecology, may influence parasite prevalence, particularly if infected butterflies are more susceptible to dry stress.

Introduction

Seasonal migration occurs in many different animal taxa, and this behavior is likely to influence the outcome of interactions between hosts and parasites. Periodic movement of hosts has been implicated in the reduction of parasite burdens in reindeer and baboons (Hausfater & Meade 1982; Folstad et al. 1991). If parasites accumulate in the hosts' environment over time, then seasonal movement may allow hosts to escape contaminated habitats. In addition, if infected hosts suffer higher mortality during migration than healthy hosts, then disease prevalence should decrease with increasing migration distance. We investigated large-scale temporal and geographic variation in the prevalence of an obligate protozoan parasite, *Ophryocystis elektroscirrha* (McLaughlin & Myers 1970) (Apicomplexa: Neogregarinida), in populations of monarch butterflies, *Danaus plexippus* (L.) (Lepidoptera: Nymphalidae). Monarchs persist in both migratory and non-migratory populations, and within the migratory populations not all generations migrate similar distances.

Thus, this system provides a unique opportunity to examine how both inter- and intra-population variation in disease prevalence relate to host movement patterns.

Eastern North American monarchs that emerge in late summer and early fall are in a state of reproductive diapause. They migrate to coniferous forests in the trans-volcanic mountains of central Mexico (Urquhart & Urquhart 1978; Brower & Malcolm 1991; Calvert & Lawton 1993; Calvert & Wagner this volume; Figure 1), arriving from late October through November, and overwinter in densely populated roosting sites that contain tens of millions of individuals (Brower & Malcolm 1991; Calvert & Lawton 1993). In February and March, these same individuals break diapause and many mate before flying north (e.g., Brower & Malcolm 1991; Van Hook 1993; Oberhauser & Frey this volume). Western North American monarchs migrate a shorter distance to the coast of California (Figure 1) and follow a similar pattern of diapause and non-diapause generations (Brower 1995), although some researchers consider the western movement to resemble a pattern of range expansion and contraction instead of true migration (Wenner & Harris 1993; Nagano et al. 1993). Individuals in a nonmigratory population in southern Florida appear to move very little throughout the course of the year, but recent evidence indicates that this population has a significant influx of fall migrants from the larger eastern population (Knight & Brower in review). Monarchs also occur in Australia, Central and South America, and many Pacific and Caribbean Islands (Ackery & Vane-Wright 1984; James 1993), with varying degrees of seasonal movement.

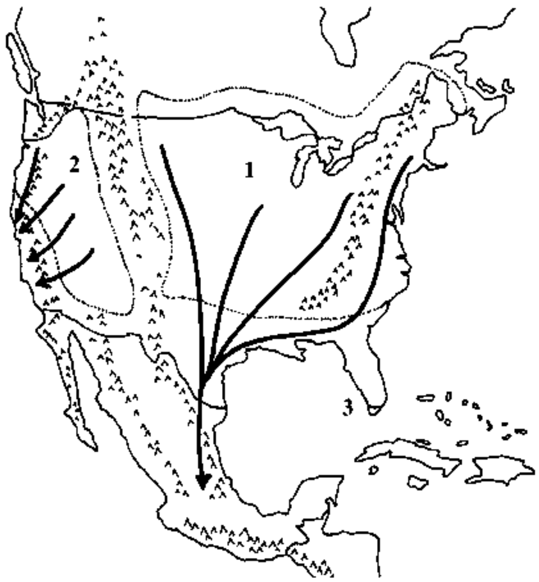

Figure 1. Summer breeding ranges and major migratory routes for three North American monarch butterfly populations: (1) eastern migratory population (2) western migratory population and (3) southern Florida population (modified from Brower 1995).

The protozoan parasite, *O. elektroscirrha*, has been reported in both eastern and western populations of North American monarchs and in *D. gilippus*, the Florida queen butterfly (McLaughlin & Myers 1970; Leong et al. 1992, 1997). The life history of *O. elektroscirrha* is correlated closely with host development. Asexual vegetative replication occurs within larvae and pupae, and sexually-produced spores are found in the developing adult integument. *O. elektroscirrha* spores must be ingested by larvae before they can break dormancy and cause new infections. Parasites are transmitted vertically (from infected females to their offspring) when spores are scattered on milkweed leaves and the surface of eggs during oviposition (McLaughlin & Myers 1970). Spores lyse in the larval gut and migrate to the hypoderm, where they undergo a form of vegetative replication. Before adults eclose, the parasite forms dormant spores around the developing integument of the adult butterfly, with the highest density of spores occurring on the distal-third of the abdomen (Leong et al. 1992). Laboratory studies have demonstrated that heavy infection with *O. elektroscirrha* increases mortality of adult monarchs, particularly under dry conditions where rates of water loss are greater (McLaughlin & Myers 1970; Leong et al. 1992; Altizer and Oberhauser in press). Heavily-infected adults have difficulty expanding their wings and often die shortly after emergence, although adults with low parasite loads appear normal (McLaughlin & Myers 1970; Leong et al. 1992). In addition to maternal parasite transmission, spores can be transferred horizontally between adults during mating or other contact (S.M. Altize in prep.).

The primary objective of the present study was to quantify variation in parasite prevalence among monarch butterfly populations with different migratory patterns. We examined parasite prevalence of North American monarchs collected over the past several decades to determine if historical patterns of prevalence are consistent with current levels. We evaluated short-term changes in parasite prevalence within eastern North America to determine whether prevalence decreases during migration or overwintering. Finally, among breeding adults collected throughout western North America, we investigated how average spore loads and parasite prevalence varies with the distance from overwintering to breeding locations.

Methods and materials

Parasite prevalence in natural populations

Parasite prevalence was assessed among adult monarchs captured from three populations in North America (Figure 1) between September, 1968 and September, 1997; several locations in Australia in 1996; and Columbia, Venezuela, and Cuba in 1995 and 1996 (Table 1). Adults were placed in individual glassine envelopes and were either held in a freezer for long-term storage, or were immediately released following testing. Butterflies in samples before 1994 were collected by L.P. Brower and his associates for other purposes and stored until we sampled them, whereas more recent collections were made explicitly for the purposes of disease assessment. Overall, we assessed disease prevalence in approximately 12,000 adults from eastern North America, 2,141 adults from western North America, 446 adults from southern Florida, 116 adults from the Caribbean and northern South America, and 108 adults from Australia.

Table 1 Location and date of monarch collections used to assess disease prevalence among populations

Population	Date	Location	Activity	N	Collector
Eastern North America	9/68	Massachusetts	Migrating	15	Brower
	9/70	Massachusetts	Migrating	36	Brower
	9/71	Massachusetts[a]	Migrating	74	Brower
	9/72	Massachusetts[a]	Migrating	153	Brower
	9/73	Massachusetts[a]	Migrating	697	Brower
	11/77–3/78	Michoacán, Mexico[ab]	Overwintering	582	Brower
	9/79	Kansas	Migrating	54	G. Otis
	1/81	Michoacán, Mexico[ab]	Overwintering	70	Calvert
	11/81	Michoacán, Mexico[ab]	Overwintering	90	Brower
	10/82	Texas[a]	Migrating	121	Calvert
	12/83	Michoacán, Mexico[ab]	Overwintering	84	Brower
	1/85	Michoacán, Mexico[ab]	Overwintering	26	Anderson
	10/85	N Florida	Migrating	50	Brower
	10/88	N Florida	Migrating	26	Van Hook
	4/93	N Florida	Migrating	42	Knight
	10/93	Texas	Migrating	134	Calvert
	11/93–3/94	Michoacán, Mexico[ab]	Overwintering	3,184	Alonso
	4/94	N Florida	Migrating	55	Knight
	7/94	Minnesota, Wisconsin[a]	Breeding	183	Altizer
	10/94	Texas, N Florida[a]	Migrating	320	Calvert Knight
	1/95–3/95	Michoacán, Mexico[ab]	Overwintering	600	Alonso
	7/95	Minnesota, Wisconsin[a]	Breeding	207	Altizer
	10/95	Texas	Migrating	48	Calvert
	11/95–3/96	Michoacán, Mexico[b]	Overwintering	3,393	Montesiños, Rendon
	7/96	Minnesota, Wisconsin[a]	Breeding	56	Altizer
	3/97	Michoacán, Mexico[b]	Overwintering	1,309	Altizer
	6/97–8/97	Minnesota, Wisconsin[a]	Breeding	370	Altizer

Table 1 (cont.) **Location and date of monarch collections used to assess disease prevalence among populations**

Population	Date	Location	Activity	N	Collector
Western North America	12/79	California Coastline	Overwintering	99	Brower
	11/89–3/90	California Coastline[ac]	Overwintering	946	Brower
	8/96	Davis, California	Breeding	40	Andolfatto
	1/97–2/97	California Coastline[ac]	Overwintering	717	Altizer
	7/97–8/97	California, Colorado, Nevada, Oregon, Utah, Washington[a]	Breeding	309	Cherubini, Gendron
	9/97	Bolinas, California	Overwintering	30	Cherubini
South Florida	12/68	Miami, Florida	Breeding	7	Brower
	11/70	Flamingo, Florida	Migrating	80	Brower
	4/90	Miami, Florida	Breeding	46	Brower
	12/94–11/95	Miami, Florida	Breeding	292	Knight
	7/96	Miami, Florida	Breeding	21	Altizer
Caribbean	11/95	Cuba		21	Dockx
	11/96	Cuba		51	Dockx
Northern South America	1/68	Trinidad	Breeding	11	Brower
	7/95	Columbia	Breeding	27	Dockx
	11/95	Venezuela	Breeding	6	Dockx
Australia	4/96	Sydney, New South Wales	Breeding	39	Zalucki
	7/96	Rockhampton, Queensland	Breeding	24	Zalucki
	7/96–10/96	Mt. Crosby, Queensland	Breeding	45	Zalucki

[a] For samples marked with an asterisk, multiple dates and locations have been combined into a single entry. Note that Mexico is included in North American collections. All other locations in eastern and western North America are from USA.

[b] Represents from 1 to 8 different overwintering areas in Central Mexico, including: Sierra Chincua, Cerro Pelon, Palomas, Sierra El Campanario, Sierra Chivati-Huacal, Cerro Altamirano, and Herrada (for locations, see Calvert & Brower 1986).

[c] Represents from 1 to 10 different overwintering locations along the California coastline, including: Bolinas, Stinson Beach, Moran Lake, Morro Bay, Pismo Beach, Ellwood, Gaviota, Leo Carillo, Cemetario, and Refugio (for locations, see Brower & Calvert, in prep.).

Many samples listed in Table 1 were collections from multiple dates or locations. For example, monarchs were collected from the eastern and western North American migratory populations at monthly or semi-monthly intervals during both reproductive and overwintering periods to assess short-term changes in disease prevalence. In summer 1997, breeding adults were collected at ten locations throughout western North America to determine whether parasite loads declined with increasing distances from overwintering sites. Dates and locations of samples used to evaluate short-term temporal and geographic variation in disease prevalence are shown in Tables 2 and 3.

Table 2 — **Samples of eastern North American migratory monarchs collected during breeding, migratory, and overwintering periods**

Location	Date	Activity	N
Cross Creek, N Florida, USA	4/93	Migrating North	42
Five sites in Central Texas, USA	10/93	Migrating South	134
Five sites in Central Mexico	11/93	Overwintering	495
Seven sites in Central Mexico	12/93	Overwintering	648
Seven sites in Central Mexico	1/94	Overwintering	705
Seven sites in Central Mexico	2/94	Overwintering	698
Six sites in Central Mexico	3/94	Overwintering	594
Cross Creek, N Florida, USA	4/94	Migrating North	55
Minnesota and Wisconsin, USA	6/94–8/94	Breeding	183
Central Texas and N Florida, USA	10/94	Migrating South	320
Four sites in Central Mexico	1/95	Overwintering	400
Sierra Chincua, Central Mexico	2/95	Overwintering	100
Sierra Chincua, Central Mexico	3/95	Overwintering	100
Minnesota and Wisconsin, USA	6/95–8/95	Breeding	207
Central Texas, USA	10/95	Migrating South	48
Sierra Chincua, Central Mexico	11/95	Overwintering	1,000
Sierra Chincua, Central Mexico	1/96	Overwintering	1,000
Sierra Chincua, Central Mexico	3/96	Overwintering	1,393
Minnesota and Wisconsin, USA	6/96–8/96	Breeding	56
Sierra Chincua, Central Mexico	3/97	Overwintering	1309
Minnesota and Wisconsin, USA	6/97–8/97	Breeding	370

Note: Unless specified, overwintering sites in Mexico include: Sierra Chincua, Cerro Pelon, Cerro Altamirano, Sierra El Campanario, Sierra Chivati-Huacal, Herrada, and Palomas. Breeding monarchs in Minnesota and Wisconsin (USA) were captured within a 100 mile radius of St. Paul, Minnesota. Migrating monarchs in Texas (USA) were captured in Central Texas.

Table 3	Collection sites, dates, and sample sizes of breeding monarchs captured in western North America (USA) in July and August 1997	
Location	**Date**	**N**
Bay Area, California	7/97	11
San Luis Obispo, California	7/97	14
El Dorado Hills, California	7/97	63
Richvale, California	8/97	28
Gazelle, California	8/97	44
Minden and Reno, Nevada	7/97	21
Talent, Oregon	8/97	23
Salt Lake City, Utah	8/97	30
Grand Junction, Colorado	8/97	25
Denver, Colorado	8/97	4
Umatilla, Oregon	8/97	11
Outlook, Washington	8/97	32

Sampling techniques

To examine butterflies for parasite loads, we used transparent Scotch™ brand tape cut into approximately 1 cm^2 units. This tape was held with fine forceps and pressed against the ventral side of the abdomen to remove a sample of abdominal scales. Each tape sample was then placed on a clear glass microscope slide or a white index card, and viewed under a microscope at 400X. Spores appear as dark brown ovals approximately 1/50 the size of a butterfly scale (Figure 2). We counted all spores on the tape and scored butterflies for parasite loads according to the following scale: 0 = no spores, 1 = 1 spore, 2 = 2 to 20 spores, 3 = 21 to 100 spores, 4 = 101–1,000 spores, and 5 = > 1,000 spores. To limit accidental spore transfer during handling of the butterflies, we used latex gloves and periodically rinsed all objects contacting the monarchs with a solution of 95% ethanol or 15% chlorine bleach.

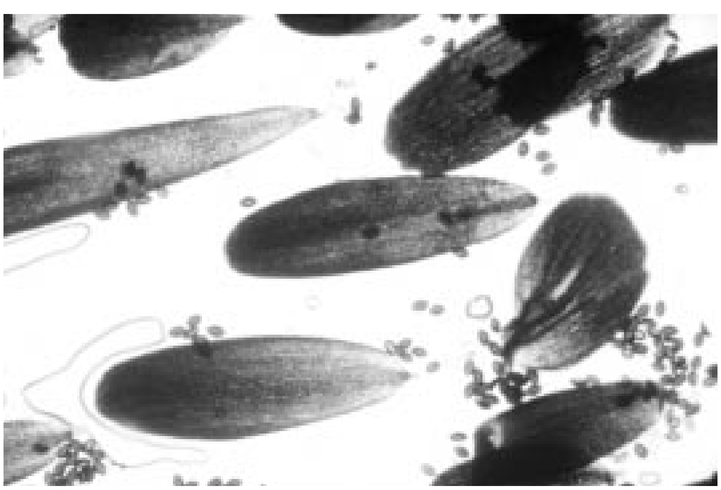

Figure 2. Spores of *O. elektroscirrha* adjacent to scales of an adult monarch (viewed under a light microscope at 400x). Photograph taken by De Cansler.

Two previous surveys of disease prevalence used a wash and count method for disease assessment (Leong et al. 1992, 1997). We have measured the correspondence between our technique and this previously published method. Parasite loads estimated using the tape method were highly correlated with the log of hemacytometer counts estimating the density of spores on monarch abdomens (Altizer et al. in press). In addition, the tape method allows for more rapid assessment of parasite loads, and does not require destructive sampling of adult monarchs.

Here, we focus primarily on patterns in the prevalence of adults with heavy parasite loads (spore classes 4 and 5). These butterflies were more likely to have been infected as larvae, and thus to have suffered any physiological costs of infection (Altizer & Oberhauser in press).

Results

Variation in parasite prevalence among North American monarch populations

Monarch populations within North America show large differences in the proportion of adults with different parasite loads. In the eastern migratory population, very few adults were infected with *O. elektroscirrha* (Figure 3a), whereas most adults in the western migratory population showed intermediate or high parasite loads (Figure 3b). All of the monarchs captured in a continuously-breeding population near Miami, Florida had *O. elektroscirrha* spores, and most of these adults were heavily-infected (Figure 3c).

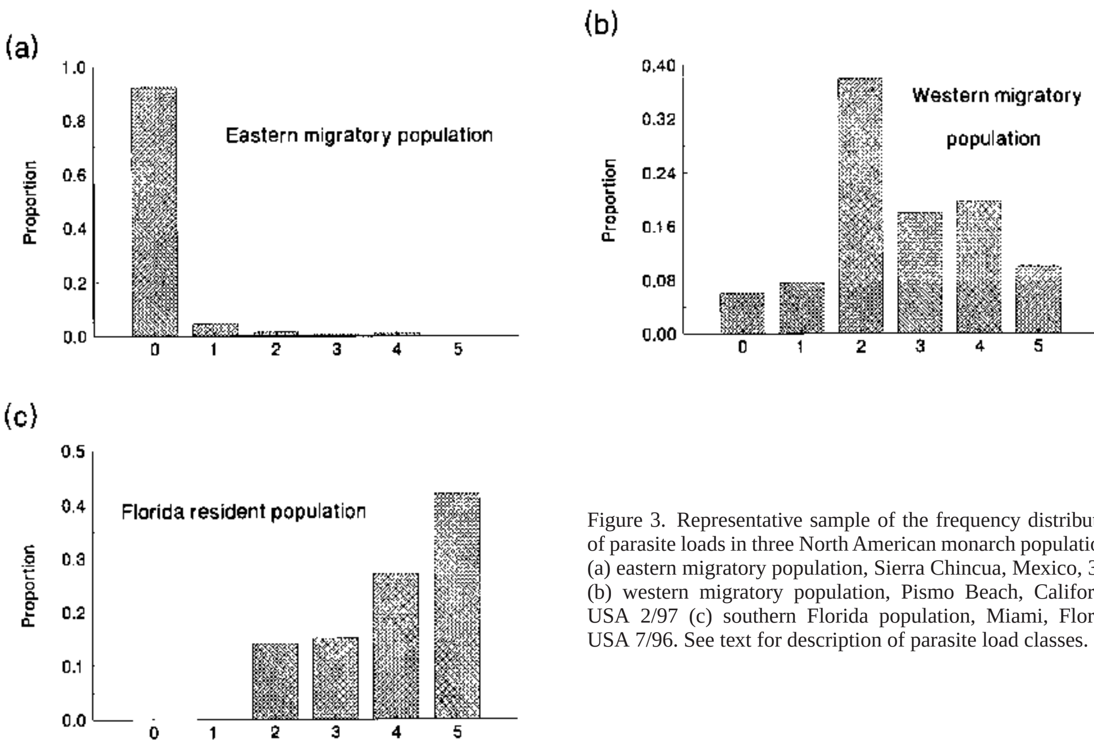

Figure 3. Representative sample of the frequency distribution of parasite loads in three North American monarch populations: (a) eastern migratory population, Sierra Chincua, Mexico, 3/97 (b) western migratory population, Pismo Beach, California, USA 2/97 (c) southern Florida population, Miami, Florida, USA 7/96. See text for description of parasite load classes.

We evaluated monarchs from past collections to determine whether the prevalence of heavily-infected adults (in classes 4 and 5) changed over time. We used logistic regression to determine whether the frequency of heavily-infected adults varied significantly across years for each of the three populations. Year was treated as either an unordered categorical variable or a continuous (quantitative) variable, to determine whether variation among years followed any consistent pattern of increase or decrease. Within the eastern migratory population, disease frequency varied over the 30-year sampling period ($\chi^2 = 48.18$, d.f. = 17, $p < 0.001$; Figure 4), although the effect of year as a quantitative variable was not significant ($\chi^2 = 2.65$, d.f. = 1, p = NS). The prevalence of heavily-infected monarchs in the eastern migratory population was always less than 8%, and was highest from 1977–1981. Year was not a significant predictor of disease frequency in the western migratory population when treated as either a categorical ($\chi^2 = 3.3$, d.f. = 3, p = NS; Figure 4) or a continuous ($\chi^2 = 0.04$, d.f. = 1, p = NS) variable. However, it is important to note that more than 10 years separate two of the western samples. In the southern Florida population, year was associated significantly with variation in disease prevalence, ($\chi^2 = 19.37$, d.f. = 3, $p < 0.005$; Figure 4), but this variation did not follow any consistent pattern over time ($\chi^2 = 2.06$, d.f. = 1, p = NS).

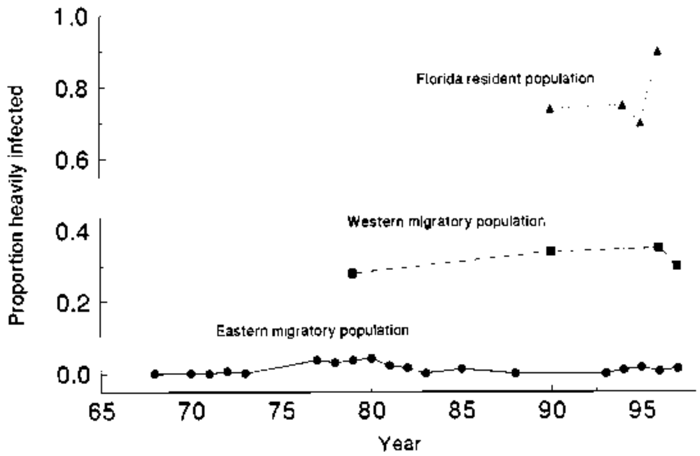

Figure 4. Prevalence of heavily-infected adults (spore classes 4 and 5) across time for each of 3 North American monarch populations: eastern migratory population (solid line), western migratory population (dotted line), and Florida resident population (dashed line). Sample sizes, locations, and dates are shown in Table 1. Each point represents all data available for a given year (if monarchs were collected at more than one site or time per year, data from all locations and times were combined).

Short-term temporal variation in parasite prevalence in eastern North America

We investigated whether the prevalence of heavy infection varied significantly with phases of breeding, migration, and overwintering in eastern North America between 1993–1997. Samples were divided into the following four categories based on the location, date, and activity of adults at the time of capture: migrating north, breeding, migrating south, and overwintering (Table 2). Although the prevalence of heavily-infected adults varied among sampling dates (Figure 5), we detected no association between activity category and the frequency of adults in spore classes 4 and 5 (χ^2 analysis; $\chi^2 = 3.54$, d.f. = 3, p = NS).

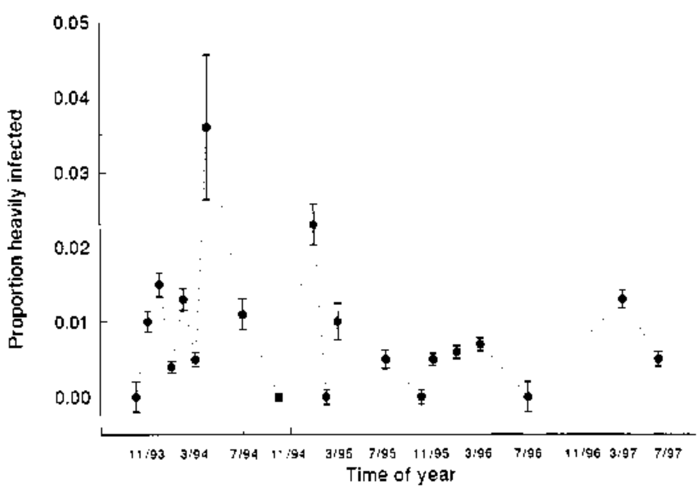

Figure 5. Short-term variation in the prevalence of heavily-infected adults in the eastern migratory population from 1993–1997. Sample sizes, dates, and locations are presented in Table 2. Overwintering periods occur from November to March, and breeding intervals are between June and August. Error bars represent 95% confidence intervals.

Spatial variation in parasite prevalence in western North America

Breeding monarchs were sampled at twelve locations throughout western North America during summer 1997 (Table 3). The distance between breeding location and the nearest overwintering colony was estimated in km. We used linear regression to examine the relationship between parasite prevalence and distance between breeding and overwintering sites. We calculated the proportion of heavily-infected adults and the average spore load of all adults for each breeding location, and arcsine-square root transformed the proportions to normalize the error variance. Analyses of both prevalence and average spore loads were weighted by the inverse of estimated variance (based on the sample sizes and spore loads of adults captured at each location). We detected a marginally significant relationship between the prevalence of heavily-infected adults and distance from overwintering sites ($b = -0.0005$, $T = -2.15$, $p = 0.057$, $r^2 = 0.32$). Average spore loads also declined with distance (Figure 6), and this association was highly significant ($b = -0.0022$, $T = -5.17$, $p < 0.001$, $r^2 = 0.73$).

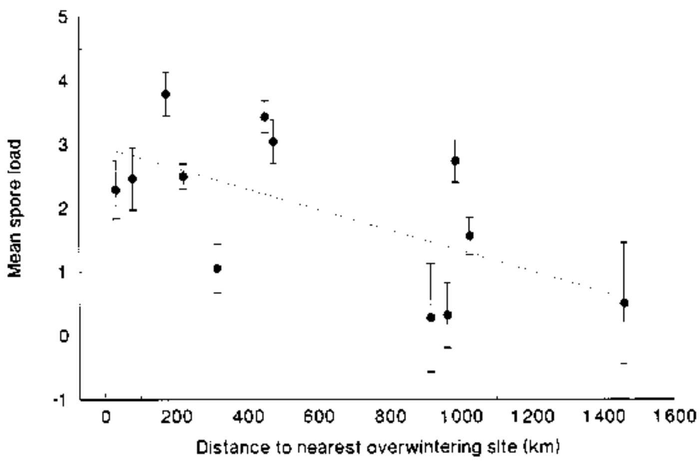

Figure 6. Variation in average spore loads among summer breeding monarchs in western North America. Distance (km) was measured between the collection site and the nearest overwintering location. Error bars show 95% confidence intervals. Sample sizes and collection sites are presented in Table 3.

Disease prevalence in other populations

O. elektroscirrha was also present in Australia and South America (Figure 7). Within Australia, the prevalence of heavy infection followed a north-south cline along the eastern coast, with monarchs from Sydney showing the highest prevalence of heavy infection (classes 4 and 5 combined = 0.39). Monarchs obtained from Mt. Crosby (near Brisbane) had a lower prevalence of heavy infection (0.27). A sample of adults from Rockhampton (the most northern sampling location) showed the lowest frequency of heavily infected adults (0.083). A χ^2 analysis of these three Australian populations showed that the proportions of heavily-infected adults were significantly different ($\chi^2 = 6.87$, d.f. = 2, $p < 0.05$).

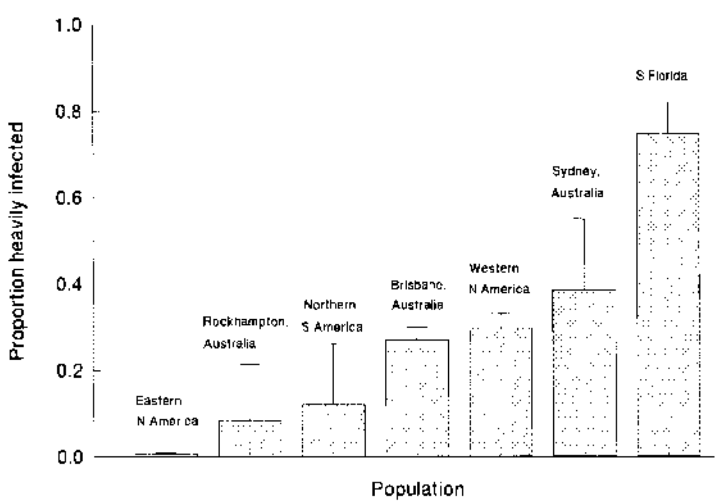

Figure 7. Population comparisons of disease prevalence for North America, South America, and Australia. Bars show the frequency of heavily infected monarchs (classes 4 and 5) with 95% confidence intervals. Sample dates and sizes for Australian and South American data are shown in Table 1. Prevalence for the eastern migratory population in North America is for March 1996, Sierra Chincua, Mexico; prevalence for the western migratory population is combined across 5 overwintering colonies along the California coast in February 1997, and prevalence for the southern Florida population is from December–April 1994.

Very few adults captured in northern South America (Colombia and Venezuela)were heavily infected with *O. elektroscirrha* (proportion = 0.11 and 0.17, respectively). The proportion of heavily-infected adults captured in Cuba during November 1995 and 1996 was approximately 0.16. In addition, no monarchs collected in Trinidad in 1968 were infected with spores, although this sample was very small (11 adults).

Discussion

The parasite *O. elektroscirrha* has a wide geographic distribution, and its prevalence is highly variable among populations. Within North America, monarchs in southern Florida display the highest parasite loads (over 70% heavily infected), whereas the migratory population in western North America is approximately 30% heavily infected. The eastern migratory population, in contrast, has less than 8% heavily infected adults. Evidence from older collections indicates that these patterns may have persisted for at least 30 years. A previous account of parasite prevalence in monarch populations, although based on smaller sample sizes, reports results similar to these (Leong et al. 1997).

The between-population differences in parasite loads we observed may be due to several factors, including genetic variation in host or parasite lineages, differences in climatic conditions between locations, and the different migratory distances flown by host populations. Our observations within North America are consistent with a pattern of decreasing parasite prevalence with increasing migratory distance. Monarchs west of the Rocky Mountains move to overwintering sites along the coast of California, and their migration distances are considerably shorter than those of the monarchs in eastern North America (Figure 1). The ecology and chemistry of monarchs collected near Miami, FL, indicate that monarchs in southern Florida breed year-round and do not migrate (Knight & Brower in review). An additional non-migratory monarch population in Hawaii has been shown to bear extremely high parasite loads (up to 100% heavily infected; Brower et al. 1995; Leong et al. 1997).

Migration may affect parasite prevalence in several ways. If migration is costly and infected hosts suffer disproportionate mortality during this process, then parasite prevalence should decrease as migratory distances or overwintering periods increase. Second, in the absence of host migration, parasites may accumulate in the hosts' environment over time. Therefore, hosts that undergo periodic migration may escape infection. Finally, migration and overwintering separate host reproductive intervals by many months, and could interrupt the transmission of parasites such as *O. elektroscirrha*, in which the primary mode of transmission is from adults to offspring.

If increased mortality of infected hosts during migration is responsible for low disease prevalence in the longest-distance migrants, we should expect disease prevalence to increase during the summer generations due to biparental transmission (Altizer & Augustine 1997), and then decline after the fall migration. However, our results of short-term changes in disease prevalence in eastern North America during intervals of breeding, migration, and overwintering do not support this prediction (Figure 5). Because disease prevalence in eastern North America is very low, and because we did not sample monarchs in this population throughout their summer range, our failure to detect significant changes between breeding and migratory intervals must be regarded with caution. Previous observations by Leong et al. (1992) on parasite loads in California overwintering monarchs also suggest that *O. elektroscirrha* does not cause increased mortality during the overwintering period alone.

In contrast, variation in parasite prevalence among breeding monarchs in western North America shows a relationship between breeding location and the likelihood of heavy infection. In general, samples collected from locations more distant from overwintering sites were associated with lower average spore loads (Figure 6). This pattern suggests that heavily-infected monarchs may fail to reach breeding sites at the most distant extremes of their range. Deviations from this general pattern suggest that other factors influence the distribution of disease among breeding monarchs in western North America. One factor that may become increasingly important is the sale and transfer of live monarchs for special events by breeders in North America. Depending on the rearing practices involved, large numbers of healthy or infected butterflies may be released and artificially decrease or enhance parasite prevalence in local patches (Brower et al. 1995).

Our study highlights the need to further investigate patterns *of O. elektroscirrha* prevalence in other parts of the world, including Central and South America, New Zealand, and Australia. Although a small proportion of monarchs captured in northern South America and Cuba were infected with this parasite, very little has been published concerning the ecology of these populations. Parasite prevalence in Australia is variable, and may relate to host movement patterns or climatic conditions. The distribution of monarchs in Australia is confined largely to eastern coastal regions of Queensland and New South Wales. Their range contracts in winter months, and stable overwintering colonies have been observed in the Sidney Basin for many years (James 1993; Zalucki and Rochester this volume). Although conditions in the Sydney area can support both breeding and overwintering monarch populations throughout the winter (James 1993), conditions near Rockhampton (in Queensland, north of Brisbane) become too hot and dry in summer to maintain a continuous breeding population (Zalucki and Rochester this volume). This variation in environmental conditions could affect the survival of infected hosts, particularly if heavily-infected monarchs are more susceptible to dry stress. Thus, both climate effects and variation in breeding ecology may relate to the higher prevalence observed in Sidney and Brisbane than in Rockhampton.

In conclusion, our large-scale observations show that parasite prevalence is lower in migratory than non-migratory monarch populations. Although fine-scale observations from the eastern migratory population do not support the differential mortality of infected hosts as a result of migration, other processes related to host migration may still play an important role in mediating parasite abundance. In particular, the observation that the distance from overwintering to breeding areas is negatively correlated with average parasite loads in western North America suggests that spring migration may be important in regulating parasite prevalence. Finally, climatic variation among populations will also influence parasite prevalence, particularly if infected butterflies are more susceptible to dry stress. Further studies will explore the relative contributions of genetic and climatic factors, in addition to migration, to variation in parasite prevalence among populations.

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Monitoreo de las colonias de mariposa monarca en sus sitios de invernación en México

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Resumen
Se monitorearon de manera constante las colonias de mariposa monarca que se encuentran dentro y fuera de la reserva de la biosfera. Ejidatarios y comuneros apoyaron el proyecto (con información, entre otras aportaciones) durante los 154 días de la invernación en México. Las colonias de invernación de la reserva se hallan una en Cerro Altamirano, tres en Sierra Chincua, tres en Sierra el Campanario, una en Chivatí-Huacal (sólo en diciembre porque después la colonia cambia de lugar) y tres en Cerro Pelón. En cuanto a las colonias que se encuentran fuera de la reserva, si bien protegidas por el decreto de 1986, se realizaron trabajos en Puerto Murrillo, Pátzcuaro, San Andrés, Puerto Berneo y Lomas de Aparicio en el estado de Michoacán, y el Picacho, Piedra Herrada, San Francisco Oxtotilpan y Palomas en el estado de México.

Introducción
Las zonas de invernación de la mariposa monarca (Danaus plexippus L.) decretadas como Reserva Especial de la Biosfera Mariposa Monarca se encuentran en el Sistema Volcánico Transversal en los paralelos 19º 15´ y 19º 45´ de latitud norte y los meridianos 100º 10´ y 100º 25´ de longitud oeste; las áreas decretadas son Cerro Altamirano, Sierra Chincua, Sierra el Campanario, Cerro Chivatí-Huacal y Cerro Pelón, que comprenden 16,110 ha, de las cuales 4,491 ha corresponden a la zona núcleo y el resto (11,619) a la zona de amortiguamiento.

Es en estas áreas en donde ocurre un fenómeno biológico único: cada año, millones de mariposas arriban a México luego de recorrer cerca de 5,000 kilómetros. Comienzan a arribar a la reserva a fines de octubre y principios de noviembre. Las mariposas forman sus colonias a una altitud de entre 3,039 msnm y, cuando las colonias están consolidadas, 3,274 msnm (García-Serrano, 1997). Las agrupaciones generalmente se forman en sitios cubiertos por bosques de oyamel (*Abies religiosa* (H.B.K.) Schl. Et. Cham.), aunque se pueden formar sobre otras especies tales como *Pinus pseudostrobus*, *Cupressus lindleyi* y *Quercus* spp. En diciembre las colonias son ya estables y así permanecerán hasta febrero —aunque se ha observado que se mueven varias veces, dependiendo de la cobertura del bosque y las condiciones climáticas (García-Serrano, 1997).

Las características climáticas y fisiográficas de las zonas, la humedad, altitud y exposición, así como las condiciones de composición, estructura y dinámica de los bosques de oyamel, son factores importantes para la sobrevivencia de la monarca.

El interés por la conservación de la mariposa en México hizo posible incluir la reserva en el proyecto Conservación de la Biodiversidad en Áreas Naturales Protegidas Selectas de México, apoyado por el Banco Mundial. Los trabajos en la reserva se inician en 1993 con una plantilla de personal que la maneja de manera permanente.

Con este apoyo el personal técnico realizó durante 1994 y 1995 dos programas de emergencia para el manejo de la reserva que incluían los proyectos Participación Comunitaria, Prevención y Combate de

Incendios Forestales, Señalización y Monitoreo de la Mariposa Monarca —este último con el objeto de conocer la localización, superficie, desplazamiento, mortalidad y comportamiento de las colonias de monarca en México.

La permanencia de las colonias de dentro y fuera de los cinco santuarios de la reserva fue constante, lo cual, junto con la información general, permitirá impulsar otras actividades que complementen el conocimiento de la dinámica de la mariposa. El objetivo del presente trabajo, entonces, fue conocer la ubicación de las colonias y la superficie ocupada (en hectáreas y árboles).

Método

1. Capacitación. A fin de que quienes participaron en las actividades de monitoreo conocieran de manera general el planteamiento del proyecto y poder disponer de la información necesaria, se realizó un taller de capacitación en las instalaciones de la Estación Central de Investigación Llano de las Papas de la REBMM. El contenido del taller incluyó la biología de la mariposa monarca, descripción general del ambiente, uso y manejo de la cartografía, manejo de formatos, escalas de nubosidad y viento, calibración y uso del material a utilizar (brújula, cinta métrica, altímetro) y determinación de los horarios de toma de datos. Fueron 34 los ejidatarios y comuneros que apoyaron las actividades de monitoreo.
2. Ubicación, superficie y desplazamiento de las colonias. Se realizaron recorridos de campo para la ubicación cartográfica y de las colonias de mariposa. Una vez localizadas, se iniciaron las actividades de monitoreo. Primero se obtuvo la forma mediante el método utilizado por Alonso *et al.* en 1993 (A. Alonso, en comunicación personal), que consiste en marcar con una cinta de plástico uno de los árboles periféricos de la colonia y desde este punto, con la ayuda de una brújula y una cinta métrica, definir el perímetro de la colonia con una serie de líneas con dirección norte respecto al punto de origen. Una vez que la colonia cambiaba de lugar se volvía a estimar el perímetro con respecto al sitio inicial. Los árboles se contaron uno a uno, y para evitar errores de conteo se tomaron transectos como referencia.
3. El área ocupada se obtuvo por medio de planimetría (Silva, en comunicación personal). En campo se realiza la poligonal de cada colonia; en este caso, la escala fue de 1:500, y con la ayuda de la malla de puntos se obtiene el número de puntos que entran en la poligonal y se multiplica por el valor de cada punto. Este valor va a depender del tamaño y de la escala de la malla de puntos.

Resultados

Para la temporada de invernación 1993-1994 sólo se monitorearon cinco colonias (véase el cuadro 1); en la de 1994-1995 se monitorearon también cinco colonias debido a que en el santuario Cerro Altamirano no se formó ninguna (cuadro 2); en la temporada de invernación 1995-1996 se monitorearon diez colonias (cuadro 3) y en la de 1996-1997 se monitorearon once (cuadro 4). Esta última temporada registró el mayor número de colonias dentro de la reserva porque en los santuarios Sierra Chincua, Sierra el Campanario y Cerro Pelón se formaron tres en cada uno.

Las colonias que se encuentran fuera de la reserva son cinco en Michoacán y cuatro en el estado de México (cuadro 5).

Cuadro 1 **Características de las colonias de invernación durante la temporada 1993-1994**

Santuarios	Árboles ocupados	Superficie (ha)	Altitud (msnm)	Latitud	Longitud	Observaciones
Cerro Altamirano						
–Cañada Oscura	87	0.43	3,090	19º58´21˝	100º08´07˝	
Cerro Altamirano						
–El Zacatonal	121	0.34	3,260	19º40´10˝	100º17´14˝	
–Mojonera Alta	175	0.49	3,280	19º40´22˝	100º17´39˝	
–Llano del Toro	496	1.40	3,200	19º40´29˝	100º18´13˝	
Sierra el Campanario						
–El Rosario	828	357	3,039	19º35´35˝	100º15´54˝	-Esta colonia es la que visitan los turistas en el ejido El Rosario.

Cuadro 2 **Características de las colonias de invernación durante la temporada 1994-1995**

Santuarios	Árboles ocupados	Superficie (ha)	Altitud (msnm)	Latitud	Longitud	Observaciones
Cerro Altamirano						
–Cañada Oscura	–	–	–	–	–	-No se encontró esta colonia durante la presente temporada.
Sierra Chincua						
–Mojonera Alta	801	2.26	3,280	19º40´22˝	100º17´39˝	-No se formó colonia en El Zacatonal y en Mojonera Alta se formaron tres colonias que posteriormente se juntaron en diciembre.
–Llano del Toro	433	1.22	3,200	19º40´29˝	100º18´13˝	
Sierra el Campanario						
–El Rosario	830	3.58	3,039	19º35´35˝	100º15´54˝	-Esta colonia es la que visitan los turistas en el ejido el Rosario
Cerro Chivatí-Huacal						
–Los Trozos	55	0.27	3,210	19º31´17˝	100º18´02˝	-Esta colonia sólo permanece hasta diciembre
Cerro Pelón						
–El Cedral	145	0.48	3,207	19º23´13˝	100º15´27˝	-También se conoce como La Agüita; sin embargo, la mayor parte de las veces la mariposa forma su colonia en el paraje El Cedral.

Cuadro 3	Características de las colonias de invernación durante la temporada 1995-1996					
Santuarios	**Árboles ocupados**	**Superficie (ha)**	**Altitud (msnm)**	**Latitud**	**Longitud**	**Observaciones**
Cerro Altamirano						
–Cañada Oscura	12	0.013	3,260	19º58´21˝	100º08´07˝	-La colonia permaneció hasta diciembre
Sierra Chincua						
–El Zacatonal	73	0.37	3,260	19º40´10˝	100º17´14˝	
–Mojonera Alta	760	2.14	3,280	19º40´22˝	100º17´39˝	
–Llano del Toro	108	1.65	3,200	19º40´29˝	100º18´13˝	-En ocasiones esta colonia se forma en el paraje conocido como "El Camino del Japonés" y a final de la temporada se junta con la de Mojonera Alta.
Sierra el Campanario						
–El Rosario	920	4.0	3,039	19º35´35˝	100º15´54˝	-Esta colonia es la que visitan los turistas en el ejido El Rosario
–Piedra Boluda	135	0.35	3,248	19º34´11˝	100º14´22˝	-Sólo permaneció hasta diciembre
Cerro Chivatí-Huacal						
–Los Trozos	150	1.5	3,210	19º31´17˝	100º18´02˝	
Cerro Pelón						
–El Cedral	1,048	1.46	3,207	19º23´13˝	100º15´27˝	-Para la presente temporada se abrió al turismo esta colonia en el ejido El Capulín.
–Cerro de las Nieves	93	0.57	3,279	19º24´12˝	100º14´14˝	
–Santa Teresa	40	0.56	3,282	19º24´36˝	100º13´54˝	

Cuadro 4 **Características de las colonias de invernación durante la temporada 1996-1997**

Santuarios	Árboles ocupados	Superficie (ha)	Altitud (msnm)	Latitud	Longitud	Observaciones
Cerro Altamirano						
–Cañada Oscura	40	0.24	3,090	19º58´21˝	100º08´07˝	
Sierra Chincua						
–El Zacatonal	641	3.10	3,260	19º40´10˝	100º17´14˝	-Esta colonia se abrió al turismo durante la presente temporada en los ejidos de Cerro Prieto y Remedios.
–Mojonera Alta	321	0.96	3,280	19º40´22˝	100º17´39˝	
–Llano del Toro	473	2.79	3,200	19º40´29˝	100º18´13˝	-Cerca se formaron dos colonias más, y posteriormente se juntaron las tres en Llano del Toro.
Sierra el Campanario						
–El Rosario	2,483	614	3,039	19º35´35˝	100º15´54˝	-Esta colonia es la que visitan los turistas en el ejido El Rosario.
–Piedra Boluda	570	0.92	3,248	19º34´11˝	100º14´22˝	-Estas dos colonias se juntan y se desplazan hacia el ejido El Rosario.
–Cerro Blanco	254	0.55	3,248	19º34´13˝	100º14´24˝	
Cerro Chivatí-Huacal						
–Mesa Chica	102	0.73	3,210	19º31´17˝	100º18´02˝	-Sólo permaneció hasta diciembre y se encuentra cerca de la colonia que se ubica en el paraje Los Trozos.
Cerro Pelón						
–El Cedral	1,031	1.48	3,207	19º23´13˝	100º15´27˝	-Para la presente temporada se abrió al turismo esta colonia en el ejido El Capulín; permaneció muy poco tiempo en este paraje antes de moverse hacia Gota de Agua.
–Carditos	34	0.28	3,110	19º23´18˝	100º15´40˝	-Sólo se ha registrado en dos ocasiones
–Santa Teresa	105	0.44	3,282	19º24´36˝	100º13´54˝	-En este paraje se formaron tres colonias que se juntaron en una sola.

Cuadro 5	Características de las colonias de invernación fuera de la reserva					
Santuarios	**Árboles ocupados**	**Superficie (ha)**	**Altitud (msnm)**	**Latitud**	**Longitud**	**Observaciones**
Estación de Michoacán						
–Puerto Morrillo	–	–	–	19º40´53˝	100º49´00˝	-Estas colonias se monitorean una vez al año y sólo se realiza una visita para los dos estados. En la temporada 1996-1997 se realizó un monitoreo más completo de las colonias ubicadas en el estado de México.
–Pizcuaro	–	–	–	19º47´45˝	100º38´57˝	
–San Andrés	35	0.035	3,227	19º42´29˝	100º48´39˝	
–Puerto Bermeo	22	0.041	–	19º44´36˝	100º08´50˝	
–Lomas de Aparicio	–	–	–	19º30´18˝	100º11´50˝	
Estado de México						
–Piedra Herrada	145	0.54	3,055	19º06´27˝	99º50´48˝	-Para ubicar las colonias del estado de Michoacán, consúltense las cartas topográficas 1:50,000 de Tzitzio, Ciudad Hidalgo y Angangueo. Para el estado de México, la carta de Temascaltepec.
–San Francisco Oxtotilpan	358	1.22	3,199	19º11´51˝	94º54´51˝	
–Palomas	226-563	1.50	3,185	19º05´53˝	99º52´06˝	
–El Picacho	–	–	–	19º33´32˝	100º13´05˝	

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Scientific research and social investigation priorities for the Monarch Butterfly Special Biosphere Reserve: Recommendations

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Introduction and background

Conservation of the Oyamel fir forests where monarch butterflies overwinter is a great challenge. Social, economical and biological information are desperately needed for proper management of the forest. Here, we first present an overview of the monarch butterfly migration and overwintering biology, and a description of the Oyamel fir forest and the causes of its degradation. We then propose research priorities with immediate actions for sustainable use of the Oyamel fir forests.

Monarch butterfly migration

Monarch butterflies (*Danaus plexippus* L.) are well-studied insects with amazing life history traits. Monarch caterpillars feed exclusively on milkweed plants (*Asclepias spp*) from which they sequester toxic chemical compounds that are poisonous to several vertebrate predators when ingested (review in Brower 1984). The bright yellow and black colored stripes of the caterpillar and the orange and black colors of the adult serve to advertise their toxicity. In addition to being one of the classical examples of aposematic coloration, monarchs are exceptional as the only insect species that performs long distance migrations of thousands of kilometers (Brower 1985, 1995).

According to Kitching et al. (1993), the subgenus *Danaus* evolved in South America during the Pliocene from an Old World ancestor. After colonizing Central America, subsequent monarch ancestors reached North America and found a highly diverse milkweed flora (Woodson 1954). During the Pleistocene, the alternating glacials and interglacials caused contractions and expansions of the geographic ranges of both fir forest and milkweed flora that may have caused migratory movements in monarch butterflies (Brower 1985, 1995). Migration and aggregation behaviors occur in other genera of the subfamily Danainae in the Old World (*Danaus* [*Salatura*], *Euploea*, *Ideopsis*, *Parantica*, and *Tirumala*), and in the New World (*Anetia*, Ivie et al. 1990; Wang and Emmel 1990; Scheermeyer 1993). Furthermore, the high numbers of monarchs that now migrate to Mexico seem to be the result of large scale deforestation that occurred in eastern North America in the 1800's (Vane-Wright 1993). According to this hypothesis, the distribution and abundance of the milkweed plant *Asclepias syriaca* L. increased in newly cleared forest. The higher availability of food resulted in an increment in the density of monarch butterflies migrating to Mexico.

Overwintering biology

Each year during the autumn, the North American population of monarch butterflies east of the Rocky Mountains migrates to several mountain peaks in central Mexico. As their larval food source of milkweed plants diminishes in North America at the end of the summer, monarchs escape the cold northern winter and migrate to the cool, moist environment of the Oyamel fir forest (*Abies religiosa* H. B. K.). Monarchs arrive in early November and form tightly packed aggregations of up to 10 million butterflies per hectare in several areas in the Transverse Neovolcanic Belt in the states of Michoacán and México (Urquhart and Urquhart 1978a; Brower 1985; Calvert and Brower 1986; Calvert et al. 1989; Calvert and Lawton 1993). There, they remain largely inactive, clustered in tree trunks and tree branches, and maintain a state of reproductive diapause until March, when they migrate back to the southern United States to exploit freshly emerging milkweed plants (Herman 1985; Brower and Malcolm 1991; Malcolm et al. 1993).

In the high altitude Oyamel fir forests, monarchs find cool ambient temperatures, where they remain quiescent for most of the five months of the overwintering period (Brower and Calvert 1985; Calvert et al. 1989). This reduces the burning of the lipid reserves that are needed for their return migration to the southern United States (Chaplin and Wells 1982; Masters et al. 1988; Alonso et al. 1997). Monarchs are periodically active when they are dislodged from tree clusters by predatory birds and winter storms, or when they fly out of the aggregation to drink water (Calvert and Cohen 1983; Calvert et al. 1983; Brower and Calvert 1985; Alonso-M. et al. 1993; Calvert 1994). Downslope colony movement to more humid areas also occurs as the dry season progresses (Calvert and Brower 1986; Calvert 1994). Lipid reserves remaining at the end of the overwintering period are used for migration and reproduction, and are probably supplemented by nectar feeding along the migration route to the southern United States (Heitzman 1962; Brower 1985; Urquhart 1987).

These high concentrations of monarchs are prime targets for several vertebrate predators. Monarch butterflies are a high quality resource for predators because low ambient temperatures make them largely inactive, and they possess large amounts of lipids (Brower 1985; Masters et al. 1988; Calvert et al. 1989; Malcolm and Brower 1989; Alonso et al. 1997). Moreover, two-to-six-month-old monarch butterflies overwintering in Mexico are poorly protected chemically since the concentration of the chemicals that provide them protection decreases with age (Alonso-M. and Brower 1994). Thus, high rates of predation have been recorded at the overwintering sites in Mexico (Calvert et al. 1979; Brower and Calvert 1985; Glendinning et al. 1988; Arellano et al. 1993; Alonso et al. 1998). Black-backed orioles (*Icterus galbula abeillei* Lesson) and black-headed grosbeaks (*Pheucticus melanocephalus* Swainson) consumed close to 9% of the Sierra Chincua monarch aggregation during the 1978–79 overwintering season (Brower and Calvert 1985). The scansorial black-eared mouse (*Peromyscus melanotis* J. A. Allen and Chapman) consumed closed to 5% of an aggregation that formed at the same site in 1986 (Alonso and Arellano 1989; Glendinning et al. 1988).

Most overwintering aggregations known to date form on the southwest facing slopes of the Mexican mountains (Calvert and Brower 1986). Southwestern slopes are usually wetter than northern and eastern slopes because moist rich air masses from the Pacific coast move into the mountains during the winter (Mosiño-Alemán and García 1974; Calvert et al. 1989). Monarchs also consistently form their aggregations at certain altitudes. At the beginning of the period, they almost never aggregate below 3,100 m. As the aggregations move to more humid areas at the middle-to-end of the overwintering period, they re-group at altitudes as low as 2,900 m (Calvert and Brower 1986). The overwintering period overlaps with the dry season which extends from November to April. The area receives more than 1,000 mm of rain during the summer wet season (Rzedowski 1983), but less than 10 mm during the dry season, with February and March being the driest months (Calvert et al. 1989).

The Oyamel fir forest

Most overwintering aggregations of monarch butterflies form in forests dominated by the Oyamel fir tree. In Mexico, Oyamel fir forests are relict of more extensive boreal-like forests which advanced during the glacial and interglacial periods of the Pleistocene. Currently, these forests have island-like distributions on mountain peaks at elevations between 2,400 and 3,600 m where colder climates prevail and other tree species such as *Pinus* L. (Pinaceae), *Quercus* L. (Fagaceae), and *Buddleia* L. occur at low densities (Madrigal 1967; Manzanilla 1974; Rzedowski 1983). *Cupressus lindleii* Klotzsch (Pinaceae) occurs in pure stands near the lower limits of the oyamel forest (Calvert et al. 1989; Soto and Vazquez 1993).

The understory vegetation consists primarily of herbaceous and bushy plant species in the Asteraceae (*Senecio spp, Eupatorium spp, Stevia spp*) and Lamiaceae (*Salvia spp*), with a diverse assortment of ascomycetes, basidiomycetes and bryophytes (Espejo et al. 1992). Ground cover includes *Acaene elongata* L., *Alchemilla procumbens* Rose (Rosaceae), and, in some areas, a carpet of mosses, including species in the genera *Thuidium* and *Mnium*. High altitude meadows *(llanos)* occur in some flat areas where the drainage is restricted, the soils freeze, and the vegetation is dominated by grasses (*Potentilla candicans* H. & B. Rosaceae) and forbs. *Llanos* are usually bordered by the bush-sized *Juniperus monticola* (Pinaceae) and by *Baccharis conferta* (Asteraceae, Snook 1993; Soto and Vazquez 1993). Attempts to reforest these *llanos* with fir trees have failed, and should not be encouraged (Snook 1993).

Oyamel trees have small needle-like leaves. This allows monarchs to cluster close to one another. Moreover, the architecture of the fir trees allows them to support heavy loads, such as ice and snow (Heinrich 1996). The branches of the Oyamel fir trees can therefore support large numbers of monarch butterflies without breaking (Alonso-M. 1996a).

Unfortunately, the ecology of the Oyamel fir tree has not been studied in detail. For example, little is known about the appropriate field conditions for seed germination and seedling establishment and survival. Basic studies are needed to understand the relationship between forest density, understory vegetation, and natural and human disturbance with respect to natural forest regeneration in Oyamel fir forests. By learning the ecology of seed production, dispersal and germination, the forest could be managed to promote natural regeneration, instead of the expensive reforestation that is so encouraged by politicians.

It is also known that fir trees can be infected by bark beetles (Scolytidae: *Scolytus hermosus*, *S. mundus*, *S. ventralis*, *Pityophthorus blackmanii*, and *Pseudohylesinus variegatus*, Hernández and Cibrián 1981), mistletoes (*Arceuthobium abietis-religiosae*, Rodríguez 1983), and periodic outbreaks of geometric moths (*Evita hyalinaria blandaria* Dyar Geometridae, Carbajal and López 1987), and that any of these infections can lead to tree mortality (Snook 1993). However, further studies on the distribution, abundance, and vertical and horizontal transmission of these diseases are needed.

Most Oyamel trees die standing, by parasitism or by lightning. Thus, small scale disturbances such as tree fall gaps are not observed in the area. During the snow storm of 1981, Calvert et al. (1983) reported that one tree was uprooted and those gaps are not common in the forest. Little is known of the effects (positive or negative) of forest fires in Oyamel trees. According to Gutiérrez (1983), most forest fires are set intentionally by cattlemen and farmers to promote new spring grass growth for their animals and to clear forested areas for planting as the agricultural frontier expands up to the mountains. The conversion of forest land to agricultural use is a key factor in forest destruction, leading to soil erosion and poor productivity (Snook 1993).

Degradation of the Oyamel forest

Oyamel trees are extracted from the forest for commercial, industrial and domestic purposes (Snook 1993). Commercial exploitation provides raw materials for local sawmills and neighboring conglomerate board and papermaking industries. Legal exploitations require the issuing of permits for extraction and transportation of authorized volumes of wood and they are carried out following the Mexican Method of Forest Control (Método Mexicano de Ordenación de Montes, Musalem 1979). This method of forest management involves a low-intensity, periodic selective cutting of 35–40% of the volume of the desired tree species. Its goal is to increase the growth of the remaining trees, enhancing production, and promoting regeneration by reforestation. However, lumbering operations in the Oyamel forests do not have a long-term sustainability goal, since forest land is decreasing and the preserved area is not large enough to allow a rotation that will permit forest regeneration. Moreover, logging temporarily destroys large areas of the understory vegetation where trees are felled and logs are transported to trucks. The method also requires reforestation practices, including training, and commitment to follow up the survival of the seedlings. Free-ranging livestock are commonly found in the area and seem to have a negative effect on the survival of oyamel fir tree seedlings (Calvert et al. 1989; Snook 1993).

According to Snook (1993), the uncontrolled timber cutting for domestic purposes can have an even higher negative effect on the degradation of the forest. She argues that significant quantities of wood are extracted for construction materials (beams and shingles “*tejamanil*”) and fuelwood (for cooking and heating purposes) by the large population of local peasants that live in the surrounding areas near the overwintering sites (i.e., about 15,000 people live in the Sierra Chincua, Campanario, and Chivati-Huacal region, data from 1990 in Chapela and Barkin 1995). She estimated that approximately 75,000 m^3/yr, or about 40,000 fir trees of average size (1–3 m^3), are taken each year. Most of the local peasant population lives at a subsistence level, deriving their food from agriculture and grazing, their fuel and construction materials from the forest, and their income from the sale of agricultural goods and wood products (Chapela and Barkin 1995). The amount, origin and destination of wood taken by each *ejido* for domestic purposes needs to be evaluated. The rate of population growth of these communities also needs to be studied and considered in future forest planning. Emigration to Mexico City seems to be high but needs to be studied (Chapela and Barkin 1995).

In addition to logging, local inhabitants obtain a limited number of non-timber products from the Oyamel forests. These include the collection of flowers for religious rituals, herb plants for medicinal purposes (e.g., “TE DE MONTE” from *Satureja macrostema*, Lamiaceae), the extraction of resin from pine trees, and the harvesting of mushrooms during the rainy season.

The restricted distribution of the Oyamel forest to high altitude mountain peaks, and the increasing pressure from logging and clearing for agricultural fields make it more vulnerable to deforestation than any other forest type in Mexico (Calvert et al. 1989; Snook 1993). The degradation of the forest endangers the migratory phenomenon of the monarch butterfly. The method of selective tree-cutting used in the overwintering areas reduces the density and canopy coverage of the forest. These forest conditions are needed to insulate the butterflies against extreme cold temperatures that occasional winter storms bring to the area, acting as an umbrella to retain heat and humidity (Calvert et al. 1983; Wells et al. 1983; Brower and Malcolm 1991; Culotta 1992; E. Rendón unpublished data; Brower this volume). Thus, logging is prohibited in several areas where monarchs overwinter.

The Monarch Butterfly Special Biosphere Reserve

The overwintering sites in Mexico were first discovered by F. A. Urquhart and colleagues after several decades of research on monarch migration (Urquhart 1976; Urquhart and Urquhart 1976). Interested in the preservation of the spectacular migratory phenomenon, the Urquharts decided not to share the exact location of their findings (Brower 1995). Despite this, the publication of popular and scientific articles on monarchs overwintering in Mexico soon made the sites known (Urquhart 1976; Brower 1977, 1985; Barthelemy 1978; Urquhart and Urquhart 1978a, b; Calvert et al. 1979; Calvert and Brower 1986).

W. Calvert and L. Brower, from the University of Florida, conducted pioneering research on the biology of monarch butterflies overwintering in Mexico. In collaboration with Leonila Vázquez and Héctor Pérez, professors of entomology at the National University of Mexico, Calvert and Brower soon learned that the Oyamel fir trees were being commercially exploited at a fast rate. They determined that the survival of overwintering monarchs was closely related to the microclimate registered in closed canopy forests, such that creating opened areas by logging enhanced monarch mortality (Calvert and Brower, 1981; Calvert and Cohen, 1983; Calvert et al., 1982, 1983).

It was not until 1986 that five forested mountain tops in the States of Michoacán (Cerro Altamirano, Sierra Chincua, Sierra Campanario, and Cerros Chivati-Huacal) and México (Cerro Pelón) were designated as protected through the creation of the Monarch Butterfly Special Biosphere Reserve (MBSBR) by the signing of a decree by Mexican President Miguel de la Madrid (*Diario Oficial* 1986). Further investigations by Calvert determined that monarchs form an additional four to seven overwintering areas, depending on the year (Calvert and Lawton 1993). These include Cerro San Andrés, Mil Cumbres, Cerro Picacho in the State of Michoacán, and Cerro las Palomas, Oxtotilpan, Cerro Piedras Chinas, and Piedra Herrada, in the State of México. Most of these overwintering aggregations form along an arc stretching from the western slopes of Volcano Nevado de Toluca in the state of México, northwest to the city of Zitácuaro and north to the Altamirano mountain in the state of Michoacán (Figure 2 in Calvert and Brower 1986; Calvert et al. 1989; Calvert and Lawton 1993). The total length of the arc from Palomas, the most easterly site, to Altamirano, the most northerly aggregation, is approximately 150 km.

The MBSBR was classified as special because of the relative small area that it protects (Halffter 1984). It includes 16,110 ha of which 11,600 ha are classified as buffer zones where forest extractions are permitted (Diario Oficial, 1986; Table 1). Therefore, logging-free wilderness areas consist only of 4,500 ha. Core areas were created for protection of the animal and plant species found in the relict Oyamel fir forests, and to serve as sources of species to recolonize logged areas in the buffer zones. In the Chincua area, 700 ha were purchased by the federal government and 80 ha were expropriated by the State of Michoacán for protection. The remaining land, nearly 15,500 ha, is communally owned land *(ejidos)* granted to more than 30 groups of organized peasants. Before 1995, when President Carlos Salinas modified the 27th article of the Mexican Constitution, *ejidos* could not be bought, sold or transferred. With the new law, *ejidos* can be divided and each *ejidatario* (owner) can sell his part except of forest lands. The decision to divide an *ejido* has to be accepted by the majority of the *ejidatarios*. *Ejidos* affected by the MBSBR have kept the same organization as if the law had not been changed.

Table 1 **Total area for the core and buffer zones for each of the five protected overwintering sites of the Monarch Butterfly Biosphere Reserve**

	Core Zone	Buffer Zone	Total
Altamirano	245	1,133	1,378
Chincua	1,060	1,636	2,696
Campanario	901	989	1,890
Chivati-Huacal	940	1,074	2,014
Pelon	1,345	6,787	8,132
Total	4,491 ha	11,619 ha	16,110 ha

The different areas of the MBSBR experienced varying degrees of tree extractions before the creation of the reserve such that monarchs currently form their overwintering aggregations in forests that contain both opened and closed areas. Calvert et al. (1989) found the tree density in the overwintering sites ranges from 90 to 620 trees/ha and the basal areas varies from 12.1 to 43.8 m^2/ha. They compared these data to previous studies on Oyamel forests in Mexico (Madrigal 1967; Manzanilla 1974), and to United States forest stands of *Abies amabilis* in the Cascade Mountains of the northwest, and *A. balsamea* in the Adirondack Mountains of the northeast (Grier et al. 1981; Sprugel 1984). They found that the forest in these previous studies had higher densities in younger and mature stands, and higher, age-related basal areas than the Mexican fir forests. They concluded that, with the possible exception of the Chincua and Herrada overwintering sites, the Oyamel fir forest stands studied have being heavily exploited for timber.

Core areas of the monarch reserve are already subject to numerous human activities. Out of the 4,500 logging-free hectares of the reserve, 1,000 are being used as centers for ecotourism, one of the major alternative incomes to *ejidatarios* (Sierra Campanario, Sierra Chincua and Cerro Pelón). Fifteen hundred hectares have been illegally logged and the remaining 2,000 ha have a mosaic of closed and open forest patches where most of the scientific research on the migrating monarchs and on the oyamel forest has been conducted. Since the MBSBR is divided into 5 reserves (*Diario Oficial* 1986), core areas are small. For these areas to serve as sources of plant and animal species for recolonization of the 11,600 ha of the buffer zone, they should be increased in size and maintained as logging-free areas. Ideally, unprotected overwintering aggregations should be incorporated into the MBSBR so that the risk of extinction of the endangered phenomenon of the monarch butterfly migration will decrease.

The challenge

Despite the mounting evidence indicating that logging is detrimental to the survival of overwintering monarchs (Calvert and Brower 1981; Calvert et al. 1982, 1989; Calvert and Cohen 1983; Brower and Malcolm 1991; Alonso-M. et al. 1992; Snook 1993; Alonso-M. 1996b; Anderson and Brower 1996), a recent argument to justify logging is that tree extraction would benefit monarchs by creating forest openings in which more plants would flower. This reasoning maintains that the increased availability of nectar could translate into fewer monarchs depleting their lipid contents, and therefore, more monarchs surviving the overwintering period (Hoth 1993, Alonso et al. 1995, 1997).

Approving logging in the relatively small and already impacted core zones of the MBSBR will be detrimental in at least three aspects. First, the objective of having core areas as a source of species for the buffer zones in a Biosphere Reserve will be lost (*Diario Oficial* 1986). Second, the economic input to the local economies will be ephemeral. Forest resources extracted from the buffer zones are not distributed in the most efficient way. Excessive middleman operations, lack of forest plantations, and illegal logging do not permit land owners who request logging permits to gain full economic benefits from the trees extracted (Calvert et al. 1989; Snook 1993). Third, altering the microclimatic conditions of the forest will result in higher mortality for overwintering monarchs (Brower this volume).

Recommendatios for scientific research and social investigations

According to Snook (1993), forest management in the MBSBR should integrate two main objectives: the maintenance and improvement of forest structure for monarch butterflies, and the development of alternative sources of material goods and income for local people who currently derive much of their livelihood from the fir forests. More studies are needed to accomplish both of these objectives. The exclusion of free-ranging livestock from the fir forests may help the first objective by improving seedling regeneration. However, cattle-raising in corrals would require extra efforts by the owners to supplement water and food. The effects of restricting livestock from forests could be tested in reserves owned by the federal government but the results would not be seen for one or two decades. Few politicians, local peasants, and researchers can afford to wait that long.

The second objective can be accomplished by studying the economical and the socio-political status of the 30 *ejidos* that are affected by the MBSBR. Most of the local people live on income derived from logging and agriculture (Chapela and Barkin 1995). Basic information on the amount, origin and destination of wood taken from the MBSBR by each *ejido* for domestic and industrial purposes needs to be evaluated. With these data, comparative studies could be conducted to see, for example, the positive or negative effects (e.g., increased income and a positive attitude toward conservation) that tourism has brought to the ejidatarios that own the forest where monarchs overwinter (Rosario and Cerro Pelón, Ejido Capulin) compared to those that do not have extra income from tourism. Studies of the rates of population growth and emigration to Mexico City would also be useful (Chapela and Barkin 1995).

A famous Mexican poet, Homero Aridjis, from the group of the 100, and Lincoln Brower have recently suggested buying or leasing the land of the MBSBR from the *ejidos* (Aridjis and Brower 1996). They argue that by privatizing the reserve, they will eliminate the logging pressures. However, the *ejidatarios* of El Rosario recently stipulated that their land is not for sale (A. Cruz personal communication, *ejidatario* of El Rosario). In addition, this model has not worked well in similar situations in other countries. In Costa Rica, the “Monteverde Conservation League” bought land to preserve cloud forest. Peasants that sold their land for large amounts of money often had to go to work for the new owner after a few years of “good life” (L. Mora personal communication). Payments over time also do not usually work, since most people do not like to have restrictions placed on the use of their money (A. Cruz personal communication, *ejidatario* of El Rosario). Finally, even if the reserve is privatized, the local people are likely to continue extracting forest products as they have done for generations. To keep people out, the army would likely need to be brought in. This would make the politics of conservation even more complicated and unpopular with the local people. We are convinced that only through education and by the implementation of wise forest management can the MBSBR be a model for conservation biology.

Scientific research

As an example to other reserves in the world, most political decisions about the MBSBR have been based in scientific studies. We need to continue generating scientific data for management (e.g., forest plantations and regeneration), to implement a long-term monitoring plan of the micro-climatic conditions of the forest stands that monarchs use (e.g., forest structure), as well as to provide continuous scientific advise. The presence of biologists in the area will facilitate open communications with local communities and *ejidos* by sharing and explaining the scientific information gathered (see García and Mora, this volume). While our focus must have a regional scale, our actions should be local. Involvement of the local communities in scientific research is important for enhancing understanding of the importance and requirements of monarch butterflies in Mexico.

For example, during the 1996–97 overwintering season, several members of the Ejido Remedios assisted with collection of microclimate data (see also Garcia this volume).

The following list includes suggestions of where scientific research attention should be foccused.

Action 1. Demography of Oyamel fir trees

The buffer zones of the reserve have been extracted for wood for several years, based on technical forestry studies required by the Mexican government. However, the regeneration status (natural and artificial) and forest structure of the Oyamel fir forests remain understudied. We propose that the demography of the Oyamel forests be investigated by comparing areas where timber extraction occurred 10, 5, and 2 years ago to areas within the core zone. This study will help us evaluate current forest practices based on the density and regeneration of the Oyamel trees. We recommend that investigators gather data from at least six locations within six overwintering areas in and out of the MBSBR to avoid pseudo-replication.

Action 2. Long-term monitoring of the population of monarchs that migrate to Mexico

As a unique case in nature, all monarch butterflies within the Eastern US population migrate and aggregate in the mountains of the Transvolcanic Belt of Mexico. Estimation of the population size of overwintering monarchs has been a challenge, due to the difficulties of finding all the colonies and testing methodologies. However, thanks to the collaboration of all interested parties, almost all overwintering sites have been located. We recommend that overwintering populations continue to be monitored using the method developed by W. Calvert. This method involves: 1) measuring the perimeter of each monarch colony, 2) counting the trees covered with monarchs to estimate the population size of monarchs migrating to Mexico, and 3) gathering the estimates at the same time during the overwintering period, between 5–20 January each year. These data are very important to understanding annual fluctuations and population trends in monarch populations.

Action 3. Long-term monitoring of forest micro-climate

Monarchs are very selective in relation to where they form their overwintering aggregations. For example, the Oyamel forest near the Ejido El Paso is generally similar to other forest areas where monarchs overwinter. However, the land at the El Paso does not have the southeastern slope nor the altitude above sea level (3,000 m) that monarchs select in other forests. Micro-climatic data (e.g., temperature, humidity, wind speed) have been gathered at the Sierra Chincua for three consecutive years. We propose to continue recording this valuable information and to extend it to the entire year not only at Sierra Chincua but also at the other overwintering sites.

Action 4. Long-term monitoring of monarch mortality in relation to forest structure

Monarch mortality fluctuates year to year, especially when winter storms hit the area. Many monarchs are eaten by birds, while others die without an apparent cause, possibly due to dehydration, lipid depletion and/or diseases. We suggest that monarch mortality be studied in relation to forest structure, microclimate, and location of overwintering aggregations in order to measure, predict, and potentially prevent future monarch mortality.

Action 5. Studies on the diseases that affect Oyamel trees

It is frequently argued that the Oyamel forest has great numbers of trees that are infested with dwarf mistletoe, bark beetles, and/or insect defoliators, and that those trees should be removed to prevent further infestations. However, little is known about the distribution, abundance, or vertical and horizontal transmission of these diseases. Since little is known about the natural population control of these diseases, careful consideration should be taken before developing chemical or removal management plans (Snook 1993). One such example would be an extensive study of the dwarf mistletoe. It is known that the dwarf mistletoe flowers in March–April and fruits are produced in October–November when the sticky seeds disperse and infect neighboring branches (Rodríguez 1983). The dwarf mistletoe can only be detected in adult trees when they produce “witches’ brooms”, or fruiting structures. The mistletoe deforms and reduces growth and seed production in mature trees, killing seedling and saplings and thus affecting natural and artificial regeneration. It also weakens the tree, making it susceptible to attack by other organisms that could lead to mortality. A detailed survey of the frequency of mistletoe infestation is needed before management decisions can be made. Observations such as the frequency of seedling regeneration in the proximity of infected trees should be made. Laboratory and field experiments should address the effects of mistletoe on seedling survival. Similar studies should be conducted on the rates of infestations by bark beetles and geometrid (Lepidoptera) defoliators.

Action 6. Production of a popular book in Spanish of monarch overwintering biology

A Spanish language book describing the overwintering biology of monarch butterflies is desperately needed to share our current knowledge about monarchs and Oyamel fir forest with the general public. Promoting a better understanding of the monarch migratory phenomenon among the local people should be a top priority. A popular book will also clarify several popular aspects of the biology of the monarch that are incorrect.

Social investigations

In addition to learning how the forest regenerates, and how monarch butterflies survive, it is crucial to understand the economic and social needs of the local inhabitants of the area. Local people are very interested in learning alternative ways to use the natural resources with minimum perturbation of the forest. The following actions should be carried out by qualified sociologists and economists to understand the micro-economy of households and small communities, with the purpose of finding practical alternatives to timber extraction. As with the scientific research, the focus must be regional, but the actions have to be at a local scale.

The following list includes suggestions of where social investigations should be foccused.

Action 1. Ecological land assessment (i.e., *ordenamiento ecológico*) of the Municipio Angangueo

A long-term plan for development of the Municipality of Angangueo has to be elaborated with the participation of the *ejidos*, communal and private land owners, with collaborative efforts of professionals in land planning, geographic information systems, and social developers. The advantage of making an ecological land assessment is to promote development based on both the physical characteristics of the terrain and current and potential land use. Besides generating jobs for local people, it also promotes the legal protection of the land designated for conservation within the agreements made by all interested parties. Ideally, this model could be used and adjusted by other municipalities located near the MBSBR.

Action 2. Development of the tree nursery of the federal zone

The current facilities at the tree nursery of the federal zone at Sierra Chincua have a great economic potential with relevant political ramifications. The tree nursery will generate jobs, it will produce trees for plantations and reforestation programs, and it could be a center for research on seedling production of coniferous species. This action will promote interactions between local people and scientists. The seedling produce can also be used for plantations of Christmas trees.

Action 3. Alternative land use

Based on the results of the social and economic studies, and the ecological land assessment, alternative land use should be implemented based on the suggestions made by the land owners. Alternative activities could include developing facilities for tourism, deer ranching (advised by professionals), and improving watering systems for plantations and agricultural practices based on soil characteristics. Pine plantations can be economically important since they grow relatively fast and the wood has a good market value. An additional value of establishing forest plantations is that soil erosion is reduced and other animal and plant species can exist there.

Conclusions

Recent studies have provided new evidence against issuing logging permits in the core areas of the MBSBR. It has been shown that logging creates openings in forest that can be detrimental to monarch survival.

The information and recommendations produced by scientists can continue to help policy makers develop sound management policies if the presidential decree MBSBR is revised. It is imperative that experts in the biology of the monarch butterfly and of the Oyamel fir forest participate in the review process of the presidential decree. The review process will provide the opportunity to promote the inclusion of all overwintering sites in the MBSBR, as well as to suggest the creation of a corridor connecting all these sites, by enlarging buffer and core zones.

Most of the alternatives to forest extractions presented here will require large amounts of money and much time. These efforts would need to have the input from all the organizations that are, for one reason or another, involved with the conservation issues of the monarch butterfly. These include the federal government of Mexico (*Instituto Nacional de Ecología and Procuraduría Federal de Protección al Medio Ambiente*), the state governments of Michoacán and México, nine counties (*municipios*), more than 30 *ejidos*, national (ProNatura, Group of the 100) and international (Wildlife Conservation and Society, World Wildlife Fund, Conservation International) conservation organizations, and national (National University of Mexico, *Universidad Autónoma Metropolitana*, *Universidad Michoacana de San Nicolas de Hidalgo*, *Colegio de México*) and international research institutions. An interdisciplinary group should be formed to carry out the actions proposed in this paper. The group should be composed by biologists, foresters, sociologist, and economists. Scientific research should begin as soon as possible and should be lead by Mexican researchers.

All of us involved in this project have the same objective: the preservation of the migratory phenomenon of the monarch butterfly and of the Oyamel fir forests, where they rest during the winter. With scientific knowledge as our base, we must now join our efforts to enhance the economic development of local communities which monarchs have visited every year for hundreds of years, so that they may continue to do so for many years to come.

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Capítulo/Chapter 2

Conservación de la mariposa monarca
Conservation of the Monarch Butterfly

Lecciones y desafíos
Lessons and Challenges

Rosendo Cerro
"Es gracias al compromiso de los campesinos que los bosques aún existen, no por los decretos de protección."

Jean Lauriault
"The conservation of the monarch must be part of a bigger plan. I think it was mentioned often here, a holistic approach, like the conservation of the ecosystem. And that which is very important, in my point of view, is that humans are an integral part of that system."

Brooks Yeager
"…without significant amounts of local involvement, no conservation program can effectively succeed."

Introducción

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La conservación eficaz depende no sólo de un sólido conocimiento biológico, sino también del reconocimiento y la comprensión de la información provista por numerosas y diversas fuentes y disciplinas. Esto lo ilustra mejor la definición de la Unión Internacional para la Conservación de la Naturaleza y otros (IUCN/UNEP/WWF, 1991): la conservación "es el manejo del uso humano de los organismos o ecosistemas para asegurar que tal uso sea sustentable. Además del uso sustentable, la conservación incluye la protección, el mantenimiento, la renovación, la restauración y el enriquecimiento de las poblaciones y los ecosistemas" (p. 210).

Los cuatro artículos incluidos en este capítulo son buenos ejemplos de los aspectos varios de la conservación y de la información de los diversos campos que se interrelacionan cuando se intenta comprender el entorno de la conservación de la mariposa monarca. Abordan la importancia de generar un conocimiento básico sobre el estado de la distribución y la conservación de los ecosistemas amenazados, como el de los bosques de abeto; explorar las posibilidades del manejo del uso forestal mediante la restauración de áreas degradadas; fortalecer a las instituciones locales que participan directamente en la conservación y el uso de los recursos naturales, y fomentar la cooperación entre los diversos niveles de gobierno y de la sociedad en general hacia una meta común de conservación.

Por fortuna, en el caso de la mariposa monarca la creciente disponibilidad de información económica, social y biológica contribuye a sentar los cimientos para la realización de actividades de conservación eficaces. Masera *et al.* llevaron a cabo un estudio fundamental (publicado en este volumen) sobre los aspectos económicos regionales relacionados con los bosques en el que se ofrece una descripción cabal de la creciente demanda de productos derivados de bosques en permanente reducción. Más aún, se ha estudiado el papel de la dinámica social (en particular las desigualdades sociales) como limitante de las posibilidades de conservación (véase Chapela y Barkin, 1995; Hoth, 1995). Desde la perspectiva biológica, sin embargo, dos temas esenciales exigen atención inmediata tanto en México cuanto en Estados Unidos, a saber: 1) comprender la dinámica natural de los bosques, y 2) conocer las características de esos hábitats más favorecidos por las monarca cuando eligen sus sitios de invernación (Hoth, 1995).

En este capítulo, el ensayo de Xavier Madrigal presenta los resultados de una de las primeras evaluaciones detalladas de los tipos de vegetación encontrados en la parte oriental del estado de Michoacán (véase también Madrigal, 1994). Su estudio cubre 250,000 hectáreas que comprenden la mayor parte de las cinco áreas protegidas para las mariposas monarca por decreto presidencial de 1986. En el ámbito de la conservación, varios aspectos básicos destacan en su estudio. Primero, la gran riqueza biológica de la región estudiada, en la que el autor identificó diez tipos de vegetación, desde matorral subtropical hasta bosques de oyamel (*Abies religiosa*), el árbol principal en que se posan las monarca durante el invierno. Segundo, si se tienen en cuenta todos los sitios, el área total cubierta por los bosques de oyamel representa 11,000 hectáreas, una quinta parte de todos los bosques de abeto que, según se calcula, posee México (Manzanilla, 1977; véase Malcolm, 1993).

La contribución de Leong (también en este capítulo) sirve muy bien para examinar la solidez de la noción de "bosque intacto", en particular porque sus datos respecto de los hábitats apoyan el argumento de que apartar zonas exclusivas para las monarca puede no ser suficiente para asegurar la conservación de esos sitios (Hoth, 1995).

La investigación de Leong es importante porque ofrece explicaciones nuevas que enriquecen el debate sobre los "bosques intactos" que han prevalecido en la literatura actual y en el discurso sobre las monarca (por ejemplo: IUCN, 1983; Anderson y Bower, 1996; Alonso *et al.*, 1997; Brower, en este volumen). Y por más dignas de elogio que nos puedan parecer estas medidas de bosques intactos, si no se justifican pueden minar las oportunidades para la conservación de largo plazo al evitar los esfuerzos de manejo de los bosques y enajenar a los lugareños de los intentos de conservación; esto se podría traducir en tensiones sociales inmediatas y penurias económicas innecesarias (véase Hoth, 1995; Merino y Alatorre, 1997; Tapia, en este volumen).

Es obvio que la noción "bosque intacto" representa una de las áreas esenciales para la conservación de la mariposa monarca. Por su importancia, este concepto puede abordarse —y refutarse— con base en la bibliografía científica en la materia, desde tres puntos de vista.

En primer lugar, el estudio de Leong, que forma parte de este capítulo, apoya la idea de que las mariposas monarca parecen beneficiarse de los claros en el bosque. A la inversa, Brower (también en este volumen) y Alonso *et al.* (1997) argumentan que sólo los densos bosques intactos proporcionan las condiciones microclimáticas que las monarca requieren para sobrevivir al invierno. Sin embargo, de acuerdo con el puñado de estudios en que se ha medido y comparado la densidad del bosque, no se han encontrado colonias de monarca en los bosques densos, sino en los moderadamente abiertos, tanto en California como en México (véase Calvert *et al*., 1986: 13; Weiss *et al.*, 1991, respectivamente).

En segundo, las áreas presentadas como intactas no lo son. En los bosques de California las condiciones han cambiado drásticamente desde el siglo pasado (véase Leong, en este capítulo; Bower, 1995a). En México los bosques también han estado sujetos a muchos cambios, hasta el punto en que Malcolm (1993:359) afirma: “Las cinco áreas principales de los sitios para invernación a que se refiere el decreto presidencial, supuestamente protegidas en su totalidad, ¡están incluidas en estos bosques sobreexplotados!" Incluso Brower (1995b:50) admite que “todos los bosques en que las monarca sobreviven al invierno están afectados”. Comentarios similares relacionados con las alteraciones de los sitios de invernación se encuentran en Calvert *et al*. (1989:43). Sorprende que en algunos estudios recientes ciertos autores hayan tomado como modelo de bosque intacto uno de los sitios alterados: el bosque de la sierra Chincua (véase Anderson y Brower, 1996; Alonso *et al*., 1997). Sin embargo, desde el enfoque conservacionista, estos estudios pueden, en realidad, sustentar la posibilidad de que un bosque que ha estado sujeto a grados de alteración moderados puede, de hecho, ofrecer condiciones adecuadas para las mariposas monarca.

Por último, el concepto de bosque intacto tiene una base científica limitada; aunque Brower (en este volumen) y otros (Anderson y Brower, 1996; Alonso *et al*., 1997) lo promueven como el principal enfoque para la conservación, sus argumentos pierden credibilidad en ausencia de parámetros básicos para definir un bosque intacto (como las características de la cubierta forestal, la densidad y la estructura).

Con los resultados de su investigación científica sobre la restauración de los hábitats para las mariposas monarca, Kingston Leong ofrece una nueva explicación sobre ese debate. Sus experimentos entrañaron la eliminación y la poda en una arboleda degradada de California. Como las mariposas respondieron favorablemente a los sitios modificados deliberadamente, los resultados de Leong evidencian que el manejo cuidadoso de los bosques puede resultar esencial para enriquecer el hábitat de invernación de las monarca.

En el ámbito económico, Barkin aborda en este capítulo la necesidad de impulsar la real participación local en los esfuerzos de conservación relacionados con los sitios de invernación de las monarca en México. A su juicio, una estrategia de desarrollo sustentable será mejor si se apoya en numerosos enfoques de arriba abajo, es decir, con el fortalecimiento de las instituciones sociales y económicas locales y mediante la diversificación de la economía local, como el ecoturismo.

Las actividades de conservación de las monarca muestran cómo el éxito de los esfuerzos puede depender de la participación de los lugareños. En los años inmediatos siguientes al descubrimiento científico de los sitios de invernación en México (Urquhart, 1976), los esfuerzos conjuntos emprendidos por el gobierno, la comunidad académica y las ONG condujeron al establecimiento en 1986 de la Reserva de la Mariposa Monarca. Sin embargo, la incomprensión de las necesidades locales y la falta de participación en el curso de los esfuerzos de planeación condujeron a incrementar el deterioro de las áreas protegidas (véase Chapela y Barkin, 1995; Hoth, 1995).

Más aún, enfoques como el de Barkin ganan cada vez más importancia en las comunidades de conservación en todo el mundo (véase Halfter, 1984; West y Brechin, 1991; Gómez-Pompa y Kaus, 1992; Toledo, 1992) y entrañan un cambio significativo de los papeles que desempeñan los agentes tradicionales más importantes.

Sin embargo, hoy en día es más factible que los gobiernos federales se conciban a sí mismos como facilitadores (o intermediarios) entre muchos otros grupos de interés, como se desprende no sólo de la contribución de Toledo (en este volumen), sino de las observaciones de Brooks Yeager en su presentación (véase este capítulo).

En su presentación, sucinta y vigorosa, Yeager analiza el dilema que enfrenta el gobierno federal estadounidense. Aunque la conservación de las monarca constituye un aspecto de la vida silvestre de clara preocupación para los gobiernos de los tres países de América del Norte, en este caso el gobierno federal de Estados Unidos tiene limitadas posibilidades de intervención, ya que la conservación de las monarca pertenece a la jurisdicción tanto de los estados como de las localidades.

Con todo, en vista de las amenazas inminentes a que se enfrentan las monarca en Estados Unidos, como lo muestra la pérdida reciente de 21 sitios de invernación en California (Lane, 1984; Nagano en Malcolm, 1987; Sakai *et al*., 1989, en Malcolm, 1993), incluido el 72% de las arboledas de invernación estudiadas por Leong (en este capítulo), Yeager arguye que el gobierno federal de Estados Unidos puede desempeñar un papel fundamental en el fomento de la investigación, el monitoreo, la difusión y la educación.

Algunos de los retos identificados por Yeager son asegurar el respaldo ciudadano y político e identificar las fuentes financieras para apoyar los programas de conservación. Estos asuntos son también importantes en Canadá y México.

En suma, los desafíos que enfrentan los esfuerzos para proteger a la mariposa monarca en todo su rango de distribución en América del Norte ponen de relieve la importancia no sólo de generar conocimiento crítico, sino también de tender puentes entre los científicos, la ciudadanía en general, las comunidades locales y los encargados de la política y del manejo de los bosques, las praderas y las tierras agrícolas en Canadá, Estados Unidos y México. Éste fue el objetivo deseado de la conferencia.

Introduction

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Effective conservation relies not only upon sound biological knowledge, but also on the recognition and understanding of information provided by many different sources and disciplines. This is best illustrated in the definition provided by the International Union for the Conservation of Nature and others (IUCN/UNEP/WWF, 1991), which states that conservation "*is the management of human use of organisms or ecosystems to ensure such use is sustainable. Besides sustainable use, conservation includes protection, maintenance, rehabilitation, restoration, and enhancement of populations and ecosystems*" (p. 210).

The four articles included in this chapter are good examples of the different aspects of conservation and of information from diverse fields, which interrelate when attempting to understand the conservation context of the monarch butterfly. They address the importance of generating basic knowledge on the distribution and conservation status of threatened ecosystems, such as the fir forests; of exploring the possibilities for managing forest use by restoring degraded areas; of strengthening local institutions directly involved in the conservation and use of natural resources; and of fostering cooperation among various levels of government and within society-at-large, towards a common conservation goal.

Fortunately, in the case of the monarch butterfly, increasing availability of economic, social and biological information is helping to build a foundation for effective conservation actions. On regional forest-related *economics*, a seminal study was recently conducted by Masera et al., (this volume), offering key insight into the growing demand for products derived from ever-shrinking forests. Furthermore, the role of *social* dynamics—particularly of social inequalities—in limiting conservation opportunities has been explored (see Chapela and Barkin 1995; Hoth 1995). From a *biological* perspective, however, there still remain two key themes that require immediate attention as much in Mexico as in the USA, namely, to understand 1) the natural dynamics of the forest, and 2) the habitat characteristics therein most favored by the monarchs when selecting their overwintering sites (Hoth 1995).

In his paper, Xavier Madrigal (this chapter) presents the results of one of the first detailed assessments ever made of the vegetation types found in the eastern part of the State of Michoacán (see also Madrigal 1994). His study area covers 250,000 hectares, encompassing most of the five monarch butterfly areas protected by the1986 presidential decree. From a conservation viewpoint, several key aspects stand out in his survey. Firstly, the great biological richness of the studied region, in which the author identified 10 vegetation types, ranging from arid shrubland to the Oyamel (*Abies religiosa*) fir forest, the main roosting tree used by overwintering monarchs. Secondly, all stands considered together, the total area covered by the Oyamel fir forest represents 11,000 hectares, or one fifth of all the fir forest estimated to exist in all of Mexico (Manzanilla 1974; see Malcolm 1993).

The contribution made by Leong (this chapter) serves well to examine the soundness of the notion of "intact forests," particularly since his habitat data supports the argument that setting aside areas for the monarch alone may not be sufficient to secure the conservation of these sites (Hoth 1995).

Leong's research is important because it offers new insight into the "intact forest" debate, which has prevailed in current monarch conservation literature and discourse (e.g., IUCN 1983; Anderson and Brower 1996; Alonso et al. 1997; Brower, this volume). And as commendable as these "intact forest" measures may sound, if unwarranted, they can undermine opportunities for long-term conservation by preempting forest management efforts and by alienating local people from conservation attempts, hence creating immediate social tensions and unnecessary economic hardship (see Hoth 1995; Merino and Alatorre 1997; Tapia this volume).

Clearly, the notion of "intact forest" represents one of the key areas in monarch butterfly conservation. Because of its cardinal importance, this notion may be addressed—and refuted—on three accounts, based upon existing scientific literature:

Firstly, Leong's research, presented in this chapter, supports the idea that monarchs seem to benefit from clearings made in the forest. Conversely, Brower (this volume) and Alonso et al. (1997) argue that only intact dense forests provide the microclimatic conditions required by overwintering monarchs. In the few studies where forest density has been measured and compared, however, monarch colonies have been found not in dense forests, but in moderately open forests, both in California and in Mexico (see Calvert et al. 1986:13; Weiss et al. 1991, respectively).

Secondly, the areas portrayed as intact are not. In California forest conditions have changed dramatically over the last century (see Leong, this chapter; Brower 1995a). In Mexico, the forests have also been exposed to many changes, to the point that Malcolm (1993:359) has already remarked that "All five of the supposedly completely protected core areas of the overwintering sites covered by the Presidential Decree are included among these overexploited forests!" Even Brower (1995b: 50) admits that "all the forests where the monarch butterfly overwinters are disturbed." Similar comments related to disturbance of the overwintering sites may be found in Calvert et al., (1989:43). Surprisingly, in recent studies, one of these disturbed forests (i.e., Sierra Chincua) has been used as the model for an intact forest by some of the same authors (see Anderson and Brower 1996; Alonso et al. 1997). From a conservation perspective, however, these studies may actually further support the possibility that a forest that has been subject to moderate degrees of disturbance may indeed offer appropriate conditions required by the monarch.

Lastly, the concept of *intact forest* has a limited scientific basis. Although Brower (this volume) and others (Anderson and Brower 1996; Alonso, et al. 1997) promote the concept of intact forest as the main approach to conservation, their argument loses credibility in the absence of basic parameters followed by the authors to define an intact forest (such as characteristic forest cover, density and structure).

By presenting the results of his scientific research dealing with habitat restoration for Monarchs, Kingston Leong provides new insight into this ongoing debate. His experiments involved the *careful* management of forests through removal and trimming of trees in a degraded grove in California. As butterflies responded favorably to the purposefully modified sites, Leong's results provide compelling evidence that careful forest management can prove essential in enhancing monarch overwintering habitat.

On the socioeconomic level, Barkin deals in this chapter with the need of supporting effective local participation in conservation efforts related to monarch overwintering sites in Mexico. According to him, a sustainable development strategy can best be accomplished through several bottom-up approaches, namely, by strengthening local social and economic institutions, and through diversification of the local economy—including ecotourism.

Monarch conservation efforts illustrate well how the success of a conservation effort can depend upon local involvement. In the years immediately following the discovery by science of the Mexican overwintering sites (Urquhart 1976), the joint efforts undertaken by government, academics and NGOs led to the establishment of the Monarch Butterfly Reserve in 1986. However, the lack of understanding of local needs and lack of local participation throughout the planning efforts led to increased deterioration of the protected areas (see Chapela and Barkin 1995; Hoth 1995).

Moreover, the importance of approaches such as Barkin's is gaining increasing recognition in the conservation community worldwide (see Halfter 1984; West and Brechin 1991; Gómez-Pompa and Kaus 1992; Toledo 1992), and entails an important shift in the roles performed by traditional key players.

Nowadays, however, federal governments are more likely to view themselves as facilitators—or brokers—among various other stakeholders, as can be perceived not only from Toledo's contribution (this volume), but also from remarks made by Brooks Yeager in his presentation (this chapter).

In his succinct yet powerful presentation, Yeager discusses the dilemma faced by the US Federal Government. Although monarch conservation constitutes a wildlife issue of clear concern to the governments of the three North American countries, in this case, the US Federal Government is limited in its capacity to intervene, since conservation of the monarch falls within the jurisdiction of both States and localities.

Nonetheless, in view of the impending threats faced by monarchs in the US, as illustrated by the recent loss of 21 monarch overwintering sites in California (Lane 1984; Nagano in Malcolm 1987; Sakai et al. 1989, cited in Malcolm 1993), including 72% of the overwintering grove studied by Leong (this chapter), Yeager argues that the US Federal Government can play a key role in encouraging research, monitoring, outreach and education.

Some of the key challenges identified by Yeager are to secure public and political support, and to identify financial sources to support conservation programs. These issues also remain relevant to Mexico and Canada.

In sum, the challenges facing conservation efforts to protect the monarch butterfly throughout its distribution range in North America highlight the importance of not only generating critical knowledge, but also of building bridges among scientists, the general public, local communities, policy makers and managers of forests, prairies and agricultural fields in Canada, the United States and Mexico. Such is the hope of this conference.

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Dos milagros: monarcas y campesinos

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Hablar de la Reserva Especial de la Biosfera Mariposa Monarca es descubrir dos milagros: la supervivencia de la mariposa y la persistencia de la población indígena y campesina. Los dos fenómenos son extraordinarios: la mariposa, por su perseverancia milenaria de emprender dos veces al año un largo vuelo de más de 5,000 kilómetros; los campesinos, por su capacidad para resistir el embate político, recrudecido en los últimos años, en contra de los productores tradicionales. En sus propias formas, cada uno batalla por la supervivencia: a conciencia de las amenazas y sin muchas armas. Pero allí están. Nuestro reto es encontrar formas para que ambos puedan prosperar mediante el enriquecimiento de la región como zona productiva y turística.

En este trabajo sentamos las bases para la formulación de una estrategia de desarrollo sustentable que aprovecharía el ecoturismo como parte de un programa diversificado de desarrollo regional. Hasta ahora el ecoturismo no sólo no ha contribuido a la prosperidad en la región, sino que ha originado todo tipo de conflictos entre los campesinos y entre éstos y los agentes externos. Un proceso sustentable exigiría al ecoturismo integrarse como parte de la base productiva que permita a las comunidades vivir mejor mientras cuidan y aprovechan los bosques.

El ecoturismo y la sustentabilidad

Al ecoturismo le corresponde una gran responsabilidad por su compromiso con la sustentabilidad. Por eso tendrá que trascender la idea convencional de ser "traslape entre el turismo naturista y el sustentable"[1] para abarcar las dimensiones sociales de la organización productiva y la conservación ambiental. Un ecoturismo exitoso tendría que ofrecer a los visitantes la oportunidad de interactuar con la naturaleza de tal manera que su visita permita preservar y aumentar las cualidades especiales del sitio y de su flora y fauna. Al mismo tiempo tendría que facilitar a los habitantes locales un nivel de vida decoroso y a los futuros visitantes la posibilidad de disfrutar los atractivos actuales. Para lograrlo, el proyecto tendrá que contemplar la ampliación y diversificación de la base productiva, de modo que los habitantes que ofrecen estos servicios alcancen un estándar de vida sustentable.

El desarrollo sustentable, tema poderoso y controvertido, ha creado metas aparentemente imposibles para políticos e impulsores del desarrollo. La dificultad radica en que, en las actuales condiciones, *¡la acumulación de riqueza crea pobreza!* Peor aun: uno y otro grupos contribuyen al deterioro; los ricos por su acceso ilimitado a recursos y fuentes de energía, y los pobres por carecer de alternativas. Entre las naciones más pobres, el abismo social no sólo les impide recurrir a los recursos naturales para aliviar su situación, sino que incluso agudiza el daño ambiental al expulsar a la gente de sus comunidades y negarle la oportunidad de construir sus propias soluciones. Por esta razón, la búsqueda de la sustentabilidad implica una doble estrategia: por una parte, se tienen que romper las cadenas que limitan a la gente que busca fortalecer sus organizaciones o crear nuevas, y usar sus escasos recursos para buscar soluciones alternativas para sus problemas; por la otra, una estrategia de desarrollo sustentable tendrá que contribuir a forjar un nuevo pacto social, cimentado en el reconocimiento de que tanto la erradicación de la pobreza como la incorporación democrática de los desamparados a las diversas estructuras productivas son impostergables.

La sustentabilidad, entonces, es una lucha por conservar la diversidad en todas sus dimensiones. Las campañas internacionales para conservar el germoplasma, proteger a las especies en peligro de extinción y crear reservas de la biosfera están multiplicándose como reacción a la creciente ofensiva de la producción depredadora; muchas de las comunidades hostigadas luchan para defender su integridad como organismo

[1] La definición ofrecida por un destacado especialista en el tema, Kreg Lindberg, de la Universidad Charles Stuart, en Australia, en grupo de discusión Internet "Green-Travel" (@igc.apc.org) el 14 de marzo de 1996, señaló: "En consideración de que el *verdadero* ecoturismo (es decir, el turismo natural realmente comprobable) es poco común, quizá nos quedemos con el ecoturismo como un objetivo."

social, sus derechos y su sobrevivencia mientras tratan de asegurar su subsistencia. La preocupación por la biodiversidad, en su sentido más amplio, abarca no sólo la flora y la fauna amenazadas, sino también la supervivencia de estas comunidades como guardianas del ambiente natural y como productoras.[2]

La autosuficiencia: un principio ineludible

La autosuficiencia es central para cualquier estrategia de sustentabilidad. La integración del sistema de comercio mundial promueve la especialización en todas las áreas productivas. En contraste, la sustentabilidad conduce a un menor grado de especialización en todas las áreas de producción y la organización social. Históricamente, la autosuficiencia alimentaria surge como una respuesta necesaria de muchas sociedades frente al peligro de depender del comercio internacional. Las ricas tradiciones culinarias ayudan a cubrir esta necesidad cuando se aplican los amplios conocimientos de las comunidades sobre las cualidades nutricionales y agroecológicas de granos, frutas, verduras, yerbas y especias. En algunas regiones, como en el oriente de Michoacán, se han aplicado políticas para desalentar la producción básica: la gente fue conducida hacia una especialización silvícola de graves consecuencias para la nutrición, el empleo y la capacidad comunitaria de mantener control sobre las tierras; la especialización forestal también trajo un deterioro ambiental con terribles consecuencias para el bienestar humano.[3]

Sin embargo, la autosuficiencia alimentaria representa sólo parte de la estrategia de diversificación productiva que es principio fundamental del movimiento sustentable. Históricamente, los campesinos no se han limitado a cultivar sus terrenos o a cualquier otra actividad productiva única; se han caracterizado más bien por la diversificación de sus actividades productivas de subsistencia. La transferencia de modelos de agricultura comercial para promover el desarrollo en el Tercer Mundo fue lo que llevó a políticas agrícolas erróneas, ignorantes de la naturaleza multifacética del sistema tradicional de producción rural. El desarrollo sustentable ha encarado directamente este problema al intentar reintroducir estrategias de diversificación, a medida que se enfrenta el problema de la escala de operación apropiada y la canasta de productos.

Una estrategia de participación democrática para la diversificación rural y el mejoramiento productivo

El desarrollo sustentable es una metodología para la reorganización productiva que incluye el aprovechamiento de experiencias de grupos locales de todo el mundo. Aunque su emprendimiento requiere de soluciones productivas arraigadas en los recursos disponibles, no podría lograrse sin una participación democrática efectiva para definir, planear e instrumentar los proyectos. La experiencia reciente ha dejado ver la importancia de crear redes de organizaciones para apoyar y defender este trabajo; sin el mutuo refuerzo de organizaciones no gubernamentales (ONG), las agrupaciones locales no serían tan eficientes a la hora de obtener fondos para sus proyectos, asistencia técnica para ponerlos en marcha y apoyo político contra la intransigencia o incredulidad de políticos e instituciones locales y nacionales (Friedmann y Rangan, 1993).

Sin embargo, el desarrollo sustentable no será aceptado fácilmente, pues implica una lucha política por el control del aparato productivo; requiere que se redefina no solo qué y cómo producimos sino además a quién le será permitido producir y con qué propósitos. Para las organizaciones que participan en proyectos de desarrollo sustentable en áreas rurales, como la Reserva de la Monarca, los conflictos giran alrededor del control de los aparatos de la política local y el poder económico, además del uso de recursos. La lucha por asegurar en este proceso una mayor participación del campesinado, la población rural, las mujeres y otras minorías en desventaja, no conduce automáticamente al desarrollo sustentable. Una amplia participación democrática es el mejor instrumento para crear las bases de una distribución más equitativa de la riqueza, y un elemento fundamental para forjar una estrategia de desarrollo sustentable. Hasta ahora no se ha permitido la participación efectiva de las comunidades en la elaboración e instrumentación de los programas de desarrollo turístico.

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[2] Para una discusión sencilla de la sustentabilidad, véase Barkin (1998).

[3] La pérdida de la capacidad de alimentarse con producción regional es un problema generalizado que conduce a malnutrición y hambruna. Ahora se reconoce que sus orígenes son en gran parte sociales más que técnicos (o de oferta); Sen (1981) es particularmente eficiente para exponer este punto. Otros han examinado en detalle el "origen social" de estrategias y crisis alimentarias (Barkin *et al*., 1991; Barraclough, 1991).

Hoy en día se buscan mecanismos para una participación más efectiva de la sociedad civil en la gestión de gobierno en México. Hay proyectos de ley oficiales para garantizar mayor seguridad institucional a las ONG y otras agrupaciones de la sociedad civil: se ha empezado a crear mecanismos de colaboración y comunicación cuya eficacia mejoró gracias a la tecnología.[4] Sin embargo, los actuales proyectos de ley también incluyen la amenaza de un mayor escrutinio por autoridades políticas y fiscales preocupadas por la creciente fuerza de este movimiento y por su mayor eficacia para desarrollar proyectos sustentables a lo largo del país.[5] Es evidente que estamos en una encrucijada importante que aumentará las probabilidades de una mayor participación popular en proyectos locales para fomentar el bienestar y la producción y, como consecuencia, iniciativas conducentes a un desarrollo más sustentable.

Autonomía local: una estrategia para la sustentabilidad

La integración global está creando oportunidades para algunos y pesadillas para muchos. En esta yuxtaposición se requiere una nueva estrategia de desarrollo rural: una que revalore la contribución de la producción tradicional y de quienes la hacen posible. En la actual economía mundial, la mayoría de productores rurales del Tercer Mundo no puede competir. A menos que se les proteja de alguna manera, sus productos tradicionales sólo hallarán mercado dentro de los estrechos confines de sus comunidades pobres, comunidades que enfrentan un destino similar.

Para forjar una base productiva que permita a las comunidades prosperar y al mismo tiempo proteger a las monarca, será necesaria una nueva estrategia. Las políticas actuales alejan a los campesinos de sus actividades tradicionales y los expulsan de sus comunidades (Barkin, Batt y DeWalt, 1991). Campesinos y comunidades indígenas requieren de apoyos efectivos para emprender las nuevas actividades productivas que les permitirán continuar viviendo y produciendo en sus propias regiones. Aun con el estricto criterio de la economía neoclásica, este apoyo no debe concebirse como un caso más de proteccionismo ineficiente, puesto que la mayor parte de los recursos tendría un mínimo o nulo costo de oportunidad para la sociedad en general.[6]

Nuestra propuesta consiste en crear una *economía local autónoma.* Si fuéramos capaces de reconocernos como una sociedad drásticamente estratificada, el país estaría en mejor condición para seguir políticas que reconozcan y saquen ventaja de estas diferencias hasta mejorar el bienestar de todos los estratos. Una estrategia que refuerce a las comunidades rurales y posibilite la diversificación productiva hará que el manejo del crecimiento sea fácil en aquellas áreas comprometidas con la economía internacional. Aun más importante, tal estrategia ofrecería a la sociedad la oportunidad efectiva de confrontar activamente los cambios

[4] La red mexicana de comunicación La Neta es un ejemplo de esfuerzo exitoso de la propia comunidad ONG por ofrecer acceso a las comunicaciones electrónicas y a la “supercarretera de la información”. Por otro lado, el Programa de las Naciones Unidas para el Desarrollo patrocina la Red de Desarrollo Sustentable, un sistema de comunicación electrónica y promoción de ONG, coordinado desde la Secretaría de Medio Ambiente, Recursos Naturales y Pesca (Semarnap).

[5] No es mera casualidad que el Banco Mundial reconozca la eficacia de las ONG. Como resultado, les ha encargado en México varios de sus proyectos de desarrollo social y el emprendimiento de algunos de desarrollo local y regional. También ha destinado fondos especiales para su participación activa en la evaluación de otros proyectos gubernamentales; sin embargo, el gobierno se muestra reticente a permitir al Banco ejercer estas partidas.

De igual manera, el GEF (Global Environmental Facility), manejado por el Banco Mundial, está incorporando varias ONG en la puesta en marcha, administración y evaluación de sus proyectos, especialmente diseñados para promover empresas sustentables; las áreas naturales protegidas constituyen regiones favorecidas para este programa que reconoce explícitamente la importancia de los principios enunciados aquí.

[6] Muchos analistas se resisten a concebir a los campesinos como productores eficientes. Según ellos, los campesinos trabajan en una escala demasiado reducida y con escasos recursos como para ser eficientes. Sin embargo, en muchas partes de México y América Latina, si los campesinos dejaran de producir, sus tierras y los insumos que utilizan no estarían disponibles para el cultivo por agricultores comerciales. Los bajos costos de oportunidad de la producción primaria en regiones dominadas por campesinos e indígenas son producto de la falta de oportunidades de empleo productivo; si se les deja solos ante la opción de acudir a la economía subterránea para subsistir, su aportación a la economía nacional será magra. La diferencia entre los criterios sociales para evaluar el costo de la producción social y la valoración del mercado deriva de la determinación de los sacrificios que la sociedad en su conjunto tendría que asumir al adoptar una u otra opción. Sunkel ofrece los avances modernos para el desarrollo de esta estrategia (Sunkel, 1993).

en la gestión ambiental y la conservación de sus recursos naturales, además de que le abriría oportunidades a los grupos particularmente capacitados y dispuestos para tal actividad.[7]

La economía política de la autonomía no es nueva. A diferencia de la versión actual que permea todas nuestras sociedades, confrontando a ricos y pobres, nuestra propuesta plantea la creación de estructuras para que el segmento de la sociedad que *elija* vivir en áreas rurales y emprender un programa alternativo de desarrollo regional encuentre el apoyo del resto de la nación. Este modelo de autonomía alterno comienza con la base heredada de la producción rural y sigue con el mejoramiento de la productividad mediante la agroecología. Además requiere de nuevas actividades productivas que aprovechen la herencia cultural y de recursos de la comunidad y de la región para el desarrollo posterior. Puesto que demanda respuestas específicas frente a un problema general, la concepción y desarrollo del programa depende en gran medida de la participación local. Mientras que los lineamientos generales son ampliamente discutidos, los detalles específicos de los programas de inversión necesitan las aportaciones directas de los productores y sus socios.

Lo nuevo es la introducción de una estrategia explícita para fortalecer la base social y económica que permita a estos grupos mayor autonomía. El reconocimiento y fomento de los grupos marginales se vuelve una alternativa que les ofrece mejores perspectivas de desarrollo. La propuesta de la economía autónoma podría mal interpretarse como una nueva encarnación de la "guerra contra la pobreza" estadounidense o el enfoque mexicano de "Solidaridad" para aliviar los peores efectos de la marginalidad. Sería un gran error; no se trata de una simple transferencia de recursos para compensar a los grupos atrasados por su pobreza, sino un conjunto integrado de proyectos productivos que ofrezca a las comunidades rurales la oportunidad de generar bienes y servicios que contribuyan a elevar sus estándares de vida mientras mejoran el ambiente en el que viven.[8]

Los límites del ecoturismo: la mariposa monarca

El vuelo de la mariposa monarca entre Canadá y México se transformó en el símbolo del proceso de integración de las tres naciones de América del Norte. El fenómeno de su invernación en México fue "descubierto" hace 20 años (1974-1976) cuando investigadores de la Universidad de Toronto, Canadá, trazaron en México la línea final del vuelo. Por supuesto, la presencia de la mariposa era conocida desde tiempos inmemoriales por los residentes locales y por un amplio segmento de la población en el oeste-centro de México. Sin embargo, fue la publicación en *National Geographic* de los detalles del trayecto de las mariposas lo que más contribuyó a la modificación de las condiciones sociales y económicas en la región.

Una vez anunciado al mundo, el espectáculo de la visita invernal del lepidóptero empezó a atraer a centenares de miles de visitantes. El decreto de la reserva especial, que se promulgó en 1986, abarcó varias zonas para "proteger" la región de las actividades humanas destructivas. Como resultado, mucha gente de la región ha venido tomando a mal a los *intrusos*, pues sus visitas anuales han incrementado la regulación gubernamental de sus vidas y ocasionado la pérdida de tierras, conflictos sociales intensos y agudización de la miseria.

Hay serios problemas económicos y sociales en el área protegida; muchos son manifestaciones locales de la crisis general de la sociedad mexicana, que dificulta la supervivencia de los pobres rurales y la defensa de sus actividades tradicionales. En el área protegida la gente resultó afectada por las medidas de conservación. La declaratoria de las zonas núcleo y de amortiguamiento en la reserva condujo a la prohibición o severa restricción de la actividad forestal tradicional sin que las comunidades recibieran compensaciones por la reclasificación de sus tierras ni oportunidades productivas alternas que les permitieran ganarse el sustento en otras partes de la región.

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7 Gran parte de la literatura referente a la participación popular señala la aportación multifacética que la incorporación productiva de los grupos marginales podría ofrecer a la sociedad (Friedmann, 1992; Friedmann y Rangan, 1993; Stiefel y Wolfe, 1994). Así como se han examinado muy poco las estrategias de sustentabilidad específicas en las comunidades rurales pobres, es evidente que muchos de los conocimientos analizados por los muy experimentados con los grupos de base (por ejemplo, Glade y Reilly, 1993) son congruentes con los principios enunciados por los teóricos y los analistas como Altieri (1987).

8 Para una discusión general, véase Barkin, 1998. Funde (1994) ofrece un programa concreto para la reconversión de El Salvador basado en los principios discutidos en este trabajo. Las propuestas de grupos como la Red Interamericana de Agricultura y Democracia contienen ejemplos específicos de iniciativas de grupos de base para desarrollar programas como los aquí propuestos. El Centro de Ecología y Desarrollo en México propone un programa de desarrollo regional que es ejemplo directo de lo que planteamos (Chapela y Barkin, 1995).

Los problemas de la región y de sus comunidades no comenzaron en 1986 ni pueden atribuirse solamente a las mariposas. Las estructuras locales de control caciquil fueron parte de la historia local desde tiempos atrás. La demanda industrial de celulosa y los mecanismos locales para concentrar la riqueza y las oportunidades, crearon presiones sobre el bosque y dividieron a las comunidades durante décadas. Las oportunidades abiertas por la expansión incontrolada del turismo y la distribución arbitraria del botín entre un grupo reducido de comuneros, agudizaron los problemas.

En este ambiente se requiere un nuevo acercamiento al desarrollo regional. Si bien hay un reconocimiento general de que el ecoturismo puede ofrecer a la gente nuevas oportunidades, queda claro que sin otras actividades productivas complementarias que creen trabajo e ingresos, los campesinos continuarán con sus actividades cotidianas tradicionales, esas que aceleran la destrucción ambiental y amenazan la viabilidad del bosque de oyamel donde la monarca pasa el invierno.

Hoy una red local de ONG y confederaciones de comunidades y grupos productivos ha decidido crear estas oportunidades luego de reconocer los enormes costos ocasionados por los conflictos entre comunidades derivados de las estrategias que la burocracia impuso. Su principal limitación, a nuestra manera de ver, es la falta de un mecanismo para desarrollar las estrategias de producción viables; necesitan información acerca de los recursos y mercados, así como un mecanismo eficaz para canalizar los recursos. Pero sin un acceso privilegiado al crédito, tampoco podrán emprender las inversiones requeridas. Las organizaciones tienen que llevar el proceso de cooperación, sustentado en una amplia participación local, a una etapa superior que consiste en crear las empresas necesarias para capitalizar el ecoturismo y para la diversificación. Éste es el camino para crear una sociedad con mayor autonomía, la alternativa en la cual el ecoturismo contribuiría al conjunto de actividades que componen el programa de desarrollo sustentable.

Hacia la creación de una capacidad para la autonomía local

La estrategia para promover una capacidad de desarrollo local autónoma y sustentable se compone, consideramos, de cuatro elementos fundamentales:

1. El reconocimiento de las comunidades locales como derechohabientes en los foros de discusión y gestión regional. Su eficacia participativa dependerá de la disponibilidad de recursos para que se involucren de manera efectiva en el desarrollo de proyectos productivos, incluida la reimplantación de sistemas tradicionales de producción de alimentos también tradicionales y otras necesidades fundamentales en dieta y organización social.
2. La diversificación de las actividades productivas. Un programa del manejo sustentable de los recursos naturales, sociales y culturales en la región podría relacionarse con la enorme demanda de la población mexicana por conocer su país y a sus procesos naturales. No es una demanda limitada a los cuatro meses de visita de la monarca. Crear el conjunto de servicios turísticos y apoyos para el manejo ambiental de los recursos regionales abriría una amplia gama de oportunidades para segmentos importantes de la región.
3. Reorganización de la actividad y los servicios turísticos. No es aceptable reforzar la estacionalidad. Las vacaciones principales de los mexicanos y el clima abren la posibilidad de que el periodo de visita a la región se extienda a todo el año. La riqueza cultural, la diversidad biológica y étnica y las diferencias ecológicas hacen factible diversificar la oferta de servicios turísticos. De esta manera se generarían recursos para remunerar las labores de manejo ambiental y se crearían sinergias entre actividades hoy antagónicas.
4. Finalmente, el reconocimiento del valor de la contribución regional para la protección de la gran cuenca hidráulica Lerma-Chapala. Si aumenta la cobertura forestal y se realizan labores de conservación es probable que la región aporte a la cuenca un volumen de agua mayor, un valor que debe reconocerse con pagos a los comuneros. De igual manera, si se pueden revertir las actuales tendencias hacia la deforestación, es probable que la región se vuelva más efectiva para transformar en oxígeno los gases de efecto invernadero (bióxido de carbono), de donde pueden resultar beneficios colaterales importantes, pues en algunas partes del norte se empieza a vender estos gases a los generadores.

Estos pasos son fundamentales para que monarcas y campesinos sigan disfrutando de las bondades de la región. Las sociedades mexicana y estadounidense han demostrado la importancia y el valor de conservar esta región de invernación. Ahora falta movilizar los recursos para que ambos milagros permanezcan.

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Restoration of an overwintering grove in Los Osos, San Luis Obispo County, California

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Abstract

Habitat management of existing overwintering sites is an essential and key component to the preservation of current mass winter aggregations of monarch butterflies in California. A study was initiated in Los Osos, San Luis Obispo County, California, in winter 1994–1995, to restore micoclimatic conditions suitable for winter aggregations by purposely modifying a degraded eucalyptus grove. The grove historically contained three clustering areas. However, no roosting butterflies had been observed during the 1992–1993 and 1993–1994 winter seasons. Approximately 5.6 hectare of the original 19.7 hectare grove were “set aside” for the monarch butterflies and the remaining portion of the grove was removed for residential dwellings. The monarch preserve included the two larger of the three historical clustering areas. One area was modified by the removal and selected trimming of tree tops and branches to provide the microclimatic conditions associated with clustering, while the other clustering area was used as an unaltered (unmodified) control. Overwintering butterflies were attracted to the altered area of the grove almost immediately during the first and second wintering season, but abandoned the grove, in both seasons, when high wind velocities from winter storms infiltrated the areas where they gathered. During winter season 1996–1997, the butterflies remained at the modified area throughout the overwintering period. In contrast, no overwintering butterflies were observed during the same three winter seasons in the control or unmodified area.

Documenting the rehabilitation of the grove to allow for mass winter aggregations of monarch butterflies is ongoing. Information obtained from this study and other studies of grove enhancement activities (i.e., Monarch Sanctuary, Pacific Grove, California) will provide the necessary data for the development of long-term management protocols in California. Preliminary results of this study indicate that overwintering butterflies respond favorably to grove modification activities and for this reason, the mass winter aggregations of monarch butterflies in California are a manageable natural resource.

Introduction

An important component in the preservation of the monarch butterflies’ migratory phenomenon is the availability of suitable overwintering sites. These sites, at least in California, are being lost due to urban development (Malcolm 1993), to the loss of trees from diseases such as the pine pitch canker, caused by the fungus *Fusarium subglutinans* (Wollenweb. & Reinking), to destructive insects such as the Australian eucalyptus borer, *Phoracanter semipunctata* (Froggatt) and to grove senescence. For these reasons, the California legislature in 1988 allocated a sum of $2 million dollars for the purchase of sensitive sites (Malcolm 1993). The “setting aside” of forested areas for the butterflies alone, however, will not ensure the continuance of a wintering habitat.

A grove is a living and dynamic entity and conditions created by trees to favor winter aggregations may persist for only 3 to 4 decades. Eventually the trees reach a stage of maturity that no longer provide conditions conducive for winter aggregations. When a grove reaches this stage, the butterflies must find other roosting areas to survive the winter, leaving a grove without wintering butterflies.

To insure the continuance of the current mass winter aggregation sites in California, overwintering habitats for monarch butterflies must not only be identified and preserved, but also purposely managed through grove enhancement and/or modification activities to favor clustering.

This study presents the preliminary results of an ongoing experiment of overwintering grove modification activities in Los Osos, San Luis County, California, USA. The modification activities were based on findings of earlier studies (Leong 1990; Leong et al. 1991; and Frey, et al. 1992) and on additional field observations of (unpublished data) aggregation behavior of overwintering butterflies. These studies have elucidated several important environmental and behavioral parameters of monarch butterflies' winter aggregations. First, overwintering butterflies, west of the Rocky Mountains, migrate to certain groves located along the California coastline to escape the freezing winter temperatures of the northern and the eastern regions of North America. Second, the butterflies are attracted to groves that offer a specific microclimatic conditions conducive for winter aggregations, rather than to the tree species (Leong 1990). Third, the butterflies formed winter aggregations on the southern exposures of trees (Frey et al. 1992) and only on trees located in an area of the grove that offered best exposures to winter sunlight and shelter from freezing temperatures and gusty winds (Leong 1990). Fourth, the location of roosting butterflies within an overwintering grove was influenced by the strength and direction of winds entering the grove, but was restricted to an area with microclimatic conditions favorable for clustering (Leong et al. 1991). The butterflies did not form winter aggregations outside of this area even though conditions suitable for clustering may exist in other areas intermittently during the overwintering season (Leong et al. 1991). Fifth, the butterfly's winter activities revolve around morning and afternoon sunlight; the morning sunlight was necessary to increase their body temperatures (Masters 1993) so that they could initiate their daily activities, such as sunning, flying, foraging for moisture and nectar, and finding mates; the afternoon sunlight was necessary for reforming their winter aggregations. The butterflies were observed to initiate cluster formation activities on foliage exposed to filtered sunlight in early afternoon (13:00 to 14:00 PST). The reforming of the clusters was associated with the declining levels of solar radiant energy (unpublished data). Lastly, winds greater or equal to 2 m/sec had a negative effect on winter aggregations. In central California wintering sites, it was not uncommon for an entire population of overwintering monarch butterflies to abandon a grove after a major winter storm with winds. Roosting butterflies were blown from their clusters or dislodged by excessive branch movements (shaking) caused by winds exceeding 2 m/sec (unpublished data). Upon dislodgment, the butterflies flew to and resettled on foliage of trees that offered better shelter from strong winds. If strong storm winds occurred in early morning hours, when ambient temperatures were below 55ºC, the dislodged butterflies would be blown to the ground and remain there until temperatures reached flight threshold. Butterflies littering the ground at the base of roosting trees were commonly observed in early morning after a winter storm. The sensitivity of the butterflies to wind movement was documented by Leong (1990), who found that trees supporting roosting butterflies were assoicated with significant lower wind velocities than trees that once supported winter aggregations.

The Monarch Lane grove was a significant winter aggregation site in central coastal California in the early and mid-1980s, having supported as many as 40,000 to 60,000 overwintering butterflies. Overwintering monarch butterflies were not observed in the grove during the 1992–1993 and 1993–1994 seasons. The grove and adjacent land were slated for development beginning in 1994. As part of the conditions of development, two of the three overwintering areas were preserved for the monarch butterflies. This development involved the removal of 72 % of the original grove and the retention of the remainder as a sanctuary for overwintering monarch butterflies. Unlike most urban development of overwintering sites, however, provisions were also provided for grove modification and for long term habitat management. The developer (Anastasi Construction Company, Inc., Redondo Beach, CA) agreed to modify the grove, based on the author's recommendations, for a period of five years to help restore conditions conducive to winter aggregations and to provide a $50,000 endowment to be used exclusively for long-term habitat management.

The objectives of this study were: (1) to determine if a degraded winter grove can be purposely modified to restore conditions suitable for winter aggregations; (2) to evaluate the habitat's recovery, based on the grove's light and wind profile and on the movement, location and the residency of the roosting butterflies; and (3) to document the microclimatic and biotic changes of the modified and the unaltered control wintering areas.

Methods and materials

The Monarch Lane grove is located in Los Osos, San Luis Obispo County, California, USA. Prior to development, the grove encompassed 19.7 hectares of dense Blue Gum eucalyptus trees (*Eucalyptus globulus* Labill.) and was surrounded by residential dwellings north, east and south of the grove, and sand dunes on the west (Fig. 1). Within the grove, overwintering butterflies had been reported in three 3 clustering areas (Fig. 1), A, B, and C; B historically supported the largest populations (≈60,000 butterflies) of overwintering butterflies, while clustering area C supported only sporadic populations of a few hundred butterflies.

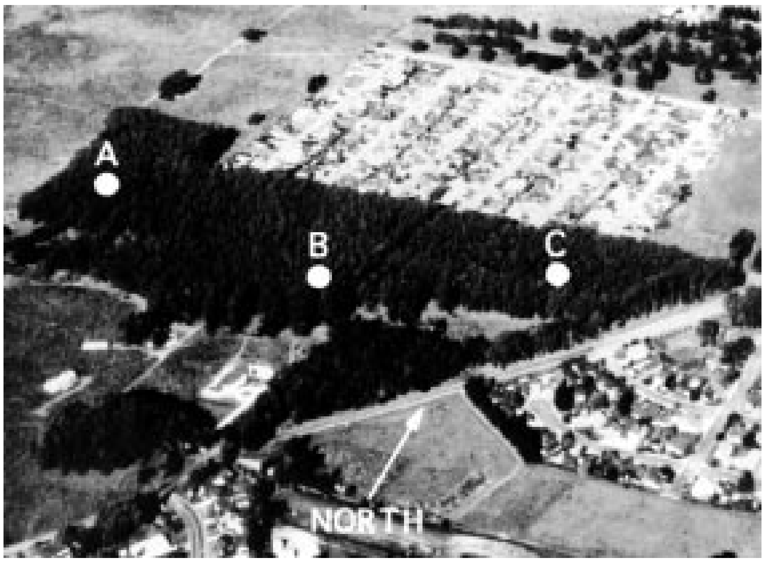


Figure 1. Predevelopmental Monarch Lane grove, showing the three historical wintering areas (A, B, & C), residential dwellings on the northern, eastern and southern borders and sand dunes on the west.

After the tree removal for residential development, the grove encompassed 5.6 hectares, with clustering areas A and B preserved for the butterflies (Fig. 2). I had the option of modifying both clustering areas for the overwintering butterflies, but decided to modify just one area and retain the other as an unmodified control. Area A was chosen to be modified because the environmental conditions of this clustering locale were known from an earlier study (Leong, et al. 1991).

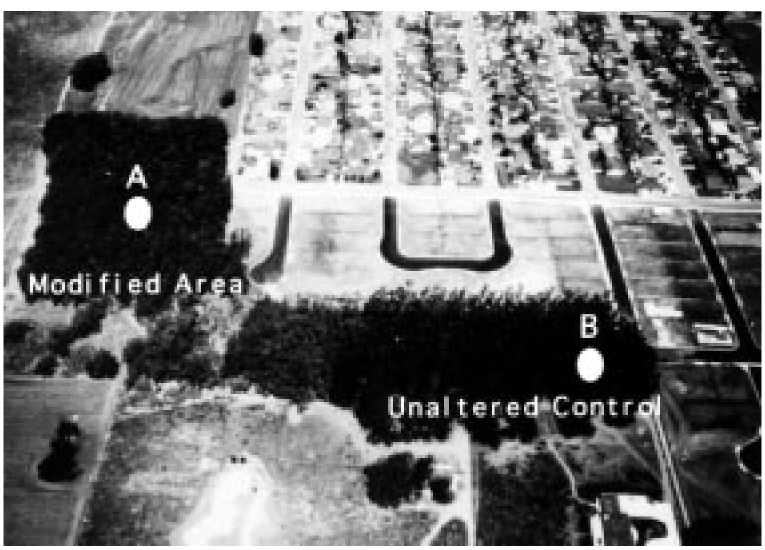
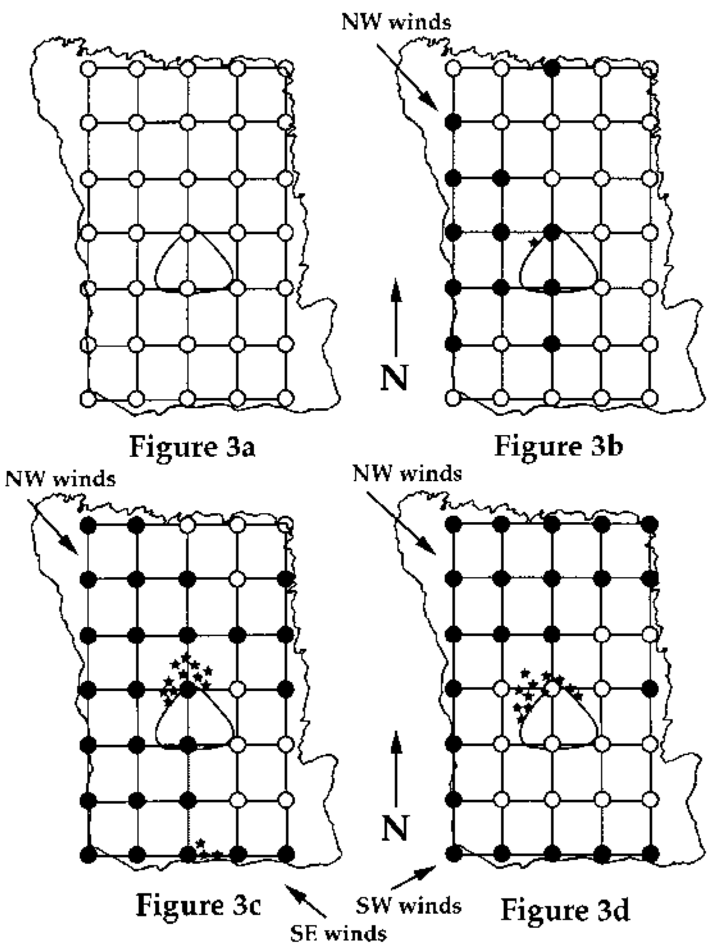


Figure 2. Postdevelopmental Monarch Lane grove, showing the wintering site A and the control site B.

Grove modifications were based on creating microclimatic conditions associated with winter aggregations (Leong 1990 & Leong, et al. 1991). These conditions included: (1) lower branches and leaves sheltered from gusty winds and freezing temperatures; (2) roosting areas exposed to filtered sunlight; and (3) sources of moisture easily accessible such as a pond, stream or morning dew.

Preliminary analyses of area A in September 1994, prior to any grove modification activities, revealed changes of two climatic parameters within the grove since the earlier study conducted during winter 1989–1990: (1) the grove trees were taller and their higher canopy prevented much of the morning and afternoon sunlight from entering the lower areas of the grove; and (2) the wind movement through the grove proper was greater; some spots, especially along the western section, recorded wind velocities of >2 m/sec.

In October 1994, a lens-shaped clearing within area A was created 60 m north of the southern border by removing all trees within a 30 m wide and 30 m deep area (Fig. 3a) to permit more sunlight into the grove. Area A was then divided into 35 sampling sites, 30 m apart (Fig. 3a) to monitor seasonal changes of the grove's environmental parameters. At each sampling site, the following were measured: (1) wet bulb, dry bulb temperatures, using a sling psychometer, to determine relative humidity and vapor pressure deficit (VPD); (2) maximum and minimum wind velocity, using a thermoanemometer during a 10-sec interval; (3) wind direction in azimuth, using a compass; (4) solar radiation, using a radiation balance meter; and (5) light intensity, using a light meter. In addition, the locations of overwintering butterfly clusters within the grove were recorded, along with the number of trees supporting butterfly clusters, the population (based on visual estimates) and the microclimatic conditions (the 5 variables measured at each sample site) associated with cluster trees. Visual estimates of the population on each tree were determined by counting the number of butterflies in a given area of a branch and multiplying this value by the total area occupied by the butterflies.



Area B (unmodified control) was divided into 15 sampling sites, 30 meters apart, and the same environmental parameters were measured at each site as in the modified area.

To obtain the seasonal environmental profile of both areas as well as the location and numbers of butterflies within the grove, the areas were monitored twice monthly, starting in the last week of October and terminating in February or when the last butterfly left the grove.

Figure 3 (a) Wintering site A, showing the open area (clear triangular area) and the 35 sampling sites. (b) Funnel-shaped pattern of sample sites, recording winds >2m/sec (indicated by dark circles) passing directly over the clustering area (represented by a star) during winter 1994–1995. (c) Winter 1995–1996, showing winds >2 m/sec (dark circles) invading the clustering areas (indicated by stars) and most of the grove proper and (d) High winds (>2m/sec) did encroach upon trees supporting winter aggregations (indicated by stars) during winter 1996–1997.

Results and discussion

The best indicators of success of any grove enhancement or modification activity are the presence (return) of overwintering butterflies and the duration of their seasonal occupancy. The key environmental factor that influences the overwintering butterflies' residency and movement within a grove is wind velocity, especially speeds approaching and exceeding 2 m/sec. Consequently, the evaluation of the modified area A and the control area B was based on two key parameters: (1) the presence, location and duration of stay of overwintering butterflies; and (2) the grove's seasonal profile of winds (> 2 m/sec). Since this paper presents the preliminary findings and evaluations of an on-going study, a detailed description of the environment in the modified and control areas will be presented in a later manuscript.

In winter 1994–1995, within a week of grove modification, 50 overwintering butterflies clustered on the foliage of two trees bordering the northwestern end of the clearing in area A (star in Figure 3b). These butterflies remained for a month and abandoned the grove when a single storm brought winds in excess of 2 m/sec. The path and possible effect of strong winds can be illustrated by shading all sample locales within the grove during the season that recorded winds of 2 m/sec or greater. As portrayed, NW winds greater than 2 m/sec traveled through the grove in a funnel pattern, directly through the clustering area (Fig. 3b). The apex of this wind funnel pattern was a dead eucalyptus tree, suggesting a breach in wind protection by the grove's perimeter trees.

Analyses of the 1994–1995 seasonal data suggested that three additional modifications were needed. First, trees bordering the northern end of the clearing were topped to provide lower branches for winter aggregations. Second, to buffer strong NW winds invading the grove proper, eucalyptus seedlings were planted, adjacent to the dead perimeter tree located along the grove's northwestern border. Third, two paths of topped trees, approximately 10 m wide and 20 m deep south of the clearing, were created to permit more sunlight into the grove. Trees south of the clearing were very tall (> 60 m) and shaded many of the trees adjacent to the clearing during morning and afternoon hours. One path was cut at ≈ 130º angle and the other was ≈ 230º to permit more morning (07:30 to 09:00) and afternoon (13:00 to 14:00) sunlight exposures to trees boarding the clearing. As discussed earlier, morning sunlight is necessary to increase the body temperatures of roosting butterflies so that they can conduct their daily activities (i.e., foraging for water, sunning, or finding mates) and the afternoon sunlight is critical for the reforming of clusters after the day's activity.

During the 1995–1996 winter season, 2,000 to 3,000 overwintering butterflies clustered in trees bordering the northern area of the clearing (starred area in Figure 3c) and they remained in the grove for three months (October to December). As in the previous season, the butterflies abandoned the grove when winds greater than 2 m/sec, passed through the area where they formed winter aggregations (Figure 3c).

During the 1996–1997 season, 3,000 to 4,000 overwintering butterflies clustered on trees bordering the clearing (stars in Figure 3d) and remained at the grove the entire wintering season. High velocity winds were not recorded in areas where the butterflies aggregated. As depicted, the butterflies clustered within an arena of favorable conditions for winter aggregations and this envelope was not violated by strong winds (Fig. 3d). The data suggest a mild winter that allowed the overwintering butterflies to remain at the grove the entire wintering season, or perhaps the return of conditions conducive for winter aggregation due to greater access to winter sunlight and to the new growth of topped trees, at least at the canopy level.

The unaltered control site, in contrast, had no overwintering butterflies during the three seasons (1994–1995, 1995–1996, & 1996–1997), and 15 of 15, 14 of 15, and 13 of 15 sample stations of respective years recorded, at least once during the winter season, winds exceeding 2 m/sec. Winds flowed almost unobstructed through control area B because the trees comprising the northern border were once inner grove trees and lack lower branches and foliage to buffer winds. The wind data for area B suggest poor wind protection as a possible key factor for the lack of overwintering butterflies at this site. However, since butterflies were not observed in the control site during the three winter seasons of study, the direct effect of winds (>2 m/sec) upon the overwintering butterflies cannot fully explain their absence. This section of the grove, for example, may currently lack the physical attributes necessary to attract migrating butterflies, even though it was once a clustering area. Trees comprising the control area were tall and had dense canopy that shaded the available few lower branches. As it was demonstrated in treatment site A, the butterflies responded favorably to grove enhancement activities that permitted more winter sunlight on wind sheltered lower branches of inner grove trees. Notably, the control area also illustrates an important example and possible weakness of the current philosophy of overwintering habitat conservation in California. The designation of a grove or a portion of the grove as a sanctuary for migrating monarch butterflies will not ensure its suitability as an overwintering habitat. A grove is a dynamic, living entity. It must be purposely managed to maintain conditions conducive for winter aggregations. The science of habitat management of overwintering sites, however, is incipient, at best. To obtain the necessary data and to develop reliable grove management protocols and decisions, studies similar to this investigation should be conducted in other overwintering sites in California and in Mexico.

Monarch butterflies are the best indicator of grove suitability, and their presence, movement and residency within the grove are key to the evaluation of any grove management program. Data presented here suggest that the butterflies are able to detect small differences in microclimatic conditions, and will cluster on trees possessing those conditions conducive for aggregations, even though the conditions associated with the trees may be ephemeral. Comparisons of the environmental conditions of trees supporting butterfly clusters during the three winter seasons after grove modification were similar to those measured in the same area in 1989–1990 (Table 1). The only difference was the vapor pressure variable; predevelopmental VPD was significantly less than the three winters after the grove was modified. The low value of VPD is reflective of a drier (less ambient RH) winter season than the three winter seasons after grove enhancement. Since roosting butterflies were present before and after grove enhancement activity, VPD variable was not a determining factor in the residency of overwintering monarchs within the grove. Notably, the cluster environmental conditions among the three seasons did not differ significantly among the 4 other variables measured, even though the butterflies abandoned the wintering area in two of the three winter seasons.

Table 1 **Comparisons of cluster micoclimatic conditions before (1989–1990) and the three seaons after grove enhancement activities**

Season	N	Light intensity (foot-candle)	Lowest wind (m/sec)	Highest wind (m/s)	Solar radiation (cal cm-2 m-1)	VPD (mm Hg)
Earlier cluster environmental parameters						
1989–1990	114	$386.80^{a} \pm 47.73$	$0.36^{a} \pm 0.02$	$0.57^{a} \pm 0.04$	$0.07^{a} \pm 0.01$	$0.01^{a} \pm 0.01$
Environmental parameters after grove enhancement activities						
1994–1995	2	$260.00^{a} \pm 120$	$0.85^{a} \pm 0.05$	$1.15^{a} \pm 0.15$	$0.09^{a} \pm 0.08$	$0.35^{b} \pm 0.00$
1995–1996	6	$158.33^{a} \pm 29.37$	$0.28^{a} \pm 0.11$	$0.42^{a} \pm 0.14$	$0.02^{a} \pm 0.00$	$0.38^{b} \pm 0.04$
1996–1997	32	$236.56^{a} \pm 29.74$	$0.36^{a} \pm 0.05$	$0.47^{a} \pm 0.06$	$0.06^{a} \pm 0.01$	$0.34^{b} \pm 0.01$
		$p = 0.27$, $F = 1.32$	$p = 0.08$, $F = 2.27$	$p = 0.06$, $F = 2.47$	$p = 0.63$; $F = 0.57$	$p < 0.01$; $F = 27.65$
		d.f. = 3, 150	d.f. = 3, 150	d.f. = 3, 150	d.f. = 3, 150	d.f. = 3, 150
Note: Means with different letter within a column are significantly different.						

As a measure of the habitat's recovery, the populations of overwintering butterflies at the study grove were compared with two neighboring wintering sites, Morro Bay, 6.8 km north, and Pismo North Beach, 30.1 km south of the study grove (Table 2). The two neighboring sites depicted similar population trends and numbers. In contrast, the populations recorded at site A did not show similar trends and had significantly lower numbers. The fact that the butterflies returned to the grove and by the third winter season remained at the site throughout the season, however, suggest a grove in recovery.

Table 2	Population estimates of overwintering monarch butterfly at three sites during three winters (1994–1997)		
	Wintering sites		
Winter season	**Monarch Lane**	**Morro Bay**	**Pismo North Beach**
1994–1995	50	20,000	15,000
1995–1996	3,000	100,000	150,000
1996–1997	4,000	60,000	40,000

Note: Population estimates of overwintering monarch butterflies recorded at Monarch Lane, Morro Bay, and Pismo North Beach wintering sites in San Luis Obispo County, California, during winters 1994–1995, 1995–1996, and 1996–1997. Estimates of populations at Pismo North Beach were based on standard mark-release-recapture, while Monarch Lane and Morro Bay were based on visual estimates.

In summary, overwintering butterflies respond favorably to the purposeful modification of a degraded winter grove. The greater accessibility of filtered sunlight into the grove helped to reestablish conditions conducive for winter aggregations. The stability of these conditions, however, was greatly influenced by the infiltration of high winds (>2 m/sec) into the cluster arena. The grove's seasonal wind profile is useful to determine where plantings of tree seedlings could be most effective in buffering future disruptive winds. Sheltering the overwintering butterflies against strong winds will greatly increase the habitat's suitability and perhaps its carrying capacity for winter aggregations.

Conclusion

The grove is still recovering and it will be years before the seedlings planted in 1995 grow to a height that can influence the wind pattern and velocity into the grove. The habitat is years away from providing the conditions to support large numbers of overwintering monarch butterflies. On the bases of the preliminary results obtained so far, three conclusions can be reached:

1. overwintering groves can be modified to favor winter aggregations;
2. butterflies respond favorably to grove modification activities; and
3. winter aggregations are manageable resources.

Acknowledgments

The author thanks Mark Kubinski and Michael Yoshimura for their editorial comments and critical review of the manuscript, Eric Wier, Charles Richardson, Chris Gerold and Anastasi Construction Company for making this study on restoration of an overwintering grove possible and Dennis Frey for data of overwintering populations at Pismo North Beach site.

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Las comunidades de vegetación primaria en el oriente de Michoacán

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Resumen
Se identificaron y caracterizaron las principales comunidades vegetales del oriente de Michoacán. Fueron registrados diez tipos de vegetación. Se indican los factores del medio físico y los agentes de alteración más importantes para las comunidades, así como algunas especies arbóreas en estado de conservación crítico.

Introducción
Utilizar y conservar los recursos naturales es en la actualidad una necesidad inaplazable frente al aumento de la población y su requerimiento de satisfactores. El mal uso y manejo de los recursos naturales se debe, entre otras causas, al desconocimiento que se tiene de los mismos. Este aspecto negativo sólo podrá modificarse con base en una mayor información científica e integral, que tenga en consideración la estrecha relación de los recursos entre sí y con los factores sociales y políticos.

Con el propósito de contribuir a este conocimiento se llevó a cabo el estudio de la vegetación en las comunidades primarias de la que fue la Unidad de Administración Forestal Núm. 1 "Ocampo-Zitácuaro", con el apoyo de fotografías aéreas, mapas de la región y exploraciones de campo. La muestra abarcó 17 sitios de 0.1 hectáreas (ha) cada uno. Con base en estos resultados (Madrigal Sánchez, 1994) y en otras observaciones se elaboró este artículo que incluye las especies arbóreas más conspicuas.

Características generales de la región
Los municipios que comprende el área estudiada se localizan en la parte NE-E-SE del estado de Michoacán, México, comprendida entre los paralelos de Greenwich 19º latitud norte y 100º 40´ longitud oeste. De norte a sur los municipios fueron: Epitacio Huerta, Contepec, Maravatío, Tlalpujahua, Senguio, Aporo, Angangueo, Ocampo, Zitácuaro, Benito Juárez y Susupuato (véase la gráfica 1).

Las 284,241 ha de superficie total se distribuyen de la siguiente forma: 37,260 ha de superficie arbolada aprovechable; 61,565 ha arboladas no aprovechables, y 185,416 ha de superficie no arbolada. Cada año se producen entre 45,000 y 60,000 m^3 de madera en rollo, y 1,400 ton de resina. El tipo de propiedad más extenso es el ejidal (48.3%), seguido por el comunal (31.0) y particular (20.7%).

En su mayor parte, la región pertenece a la Provincia del Eje Neovolcánico, Subprovincia de Mil Cumbres. Es de relieve accidentado, con altitudes extremas de entre 1,000 y 3,600 msnm (INEGI, 1985). Se considera un sistema montañoso de formación reciente debido a la predominancia de rocas ígneas efusivas de basalto, andesitas, riolitas, dioritas, tobas, además de granitos, esquistos, pizarras y materiales de aluvión (Flores, 1946).

El clima se relaciona estrechamente con la presencia de montañas y sierras de relieve escarpado. En la parte baja del extremo norte y la parte central, las isotermas varían de 16 a 18 ºC; en las áreas montañosas de los municipios Epitacio Huerta, Contepec, Maravatío y Senguio son de 14-16 ºC; en las partes elevadas del centro se estiman en 10-12 ºC, y en Zitácuaro (SW), Benito Juárez y Susupuato alcanzan entre 18 y 24 ºC.

* El autor agradece a Yolanda Chávez Huerta y Alberto F. Gómez-Tagle Rojas su apoyo en la elaboración del manuscrito, y a Estela Coria Arreola (INIFAP-Michoacán) la transcripción.

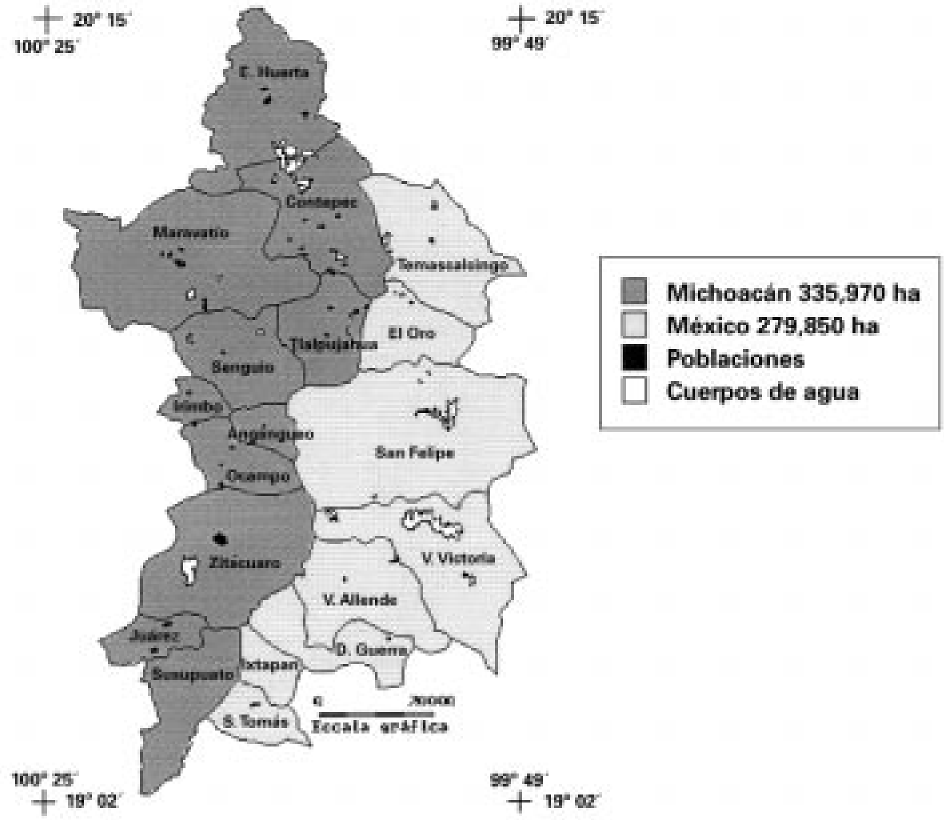

Figura 1. Municipios, Región Mariposa Monarca, México

La precipitación total anual predominante en el área de estudio es de 800 mm, con variaciones de 700-1,100 mm anuales, y se registran climas cálidos (A), semicálidos (AC) y templados (C).

El área de estudio se encuentra entre dos regiones hidrológicas: Lerma-Chapala-Santiago y la del Balsas, separadas por las sierras de Angangueo y Chincua. A la primera región pertenecen los ríos Tlalpujahua, Oro, Cachití, Las Minas, San Ramón, Chincua y Lerma (en el que desembocan todos los anteriores). En la región del Balsas corren los ríos Tuxpan, Zitácuaro, Turundeo, Trojes y Susupuato. Hay además cinco presas de importancia por su capacidad de almacenamiento que beneficia al riego y genera energía eléctrica.

Con base en la clasificación propuesta por la FAO/Unesco (1968), complementada con las descripciones de INEGI (1985), los suelos más comunes son feozem, planosol, vertisol en la parte baja del norte de la región, y andosoles y luvisoles en las montañas; en la parte central son también andosoles y luvisoles y, en menor proporción, litosoles y vertisoles; en las serranías, andosoles y, en menor proporción, luvisoles, feozem y cambisoles.

Vegetación

Se identificaron diez tipos de vegetación: matorral subtropical, selva baja caducifolia, selva mediana subcaducifolia, bosque de encino, bosque de pino-encino, bosque de aile-pino, bosque de cedro, bosque de oyamel, bosque mesófilo de montaña y bosque de galería. En el área de estudio, el bosque de tázcate no forma agrupaciones propiamente, pero sí en áreas contiguas: en el municipio de Tuxpan (*Juniperus flaccida*), escasos (*J. Deppeana*) en Tlalpujahua y una comunidad arbustiva (*J. monticola*) en el llano Las Papas, municipio de Angangueo, de características únicas en la región.

Matorral subtropical. Superficie: 11,630 ha. Se distribuye sobre todo en la parte norte del área explorada, en altitud aproximada de 2,000 msnm. Actualmente se encuentra muy alterado por las actividades agrícolas y el pastoreo. Especies arbóreas: *Cedrela dugesii, Zanthoxylum fagara, Forestiera phyllyreoides, Bursera cuneata, Erythrina coralloides, Casimiroa edulis, Ipomoea murucoides*. La altura aproximada es de 5-7 m. Vegetación que sirve principalmente al pastoreo y la explotación local de algunas especies de madera.

Selva baja caducifolia. Superficie: 13,960 ha. Se encuentra solamente en la parte sur del área de estudio. Las especies que la constituyen tienen una altura máxima de 15 m y tiran la hoja en la época seca del año. Especies arbóreas: *Bursera* spp., *Lysiloma microphyllum, Ceiba parvifolia, Spondias purpurea, Stenocereus* sp, *Cordia elaeagnoides, Ficus petiolaris* y *Tabebuia palmeri*. Crece en terrenos muy accidentados, sirve ampliamente al pastoreo de bovinos y a la agricultura de temporal.

Selva mediana subcaducifolia. Superficie: 2,500 ha. Se localiza también en la parte sur solamente, en las cañadas profundas y húmedas con diferentes grados de pendiente. Las especies arbóreas tienen aproximadamente 25 m de altura y las más comunes son: *Enterolobium cyclocarpum, Pithecellobium dulce, Ficus cotinifolia, F. padifolia, Platymiscium lasiocarpum, Tabebuia rosea, Mastichodendron capiri, Swietenia humilis, Vitex mollis, Bursera* spp., *Inga eriocarpa*. Estas superficies se dedican con frecuencia al cultivo de frutales y la extracción de madera para usos locales.

Bosque de encino. Superficie: 12,060 ha. Con esta denominación quedan comprendidas varias comunidades en condiciones ecológicas diferentes, aunque en todos los casos las especies dominantes corresponden al género *Quercus*, con alturas promedio aproximadas de 7-12 m. Estos bosques se agrupan en los de menor altitud y humedad, los de condiciones opuestas y aquellos de situación intermedia. Se localizan principalmente en las laderas de cerros. Las especies más abundantes son *Quercus resinosa, Q. conspersa, Q. obtusata* y *Q. castanea*. La madera se utiliza en forma local para postes, leña, carbón, construcciones rústicas y en pequeña escala para la industria.

Bosque de pino-encino. Superficie: 31,540 ha. Es el tipo de vegetación más ampliamente distribuido y presenta también diferentes variantes ecológicas. Se encuentra sobre todo en laderas de cerros. De esta comunidad se obtienen los mayores volúmenes de madera, principalmente de pino (*Pinus*) y en cantidad mucho menor de encino (*Quercus*). Las especies de Pinus registradas son *P. pringlei, P. oocarpa, P. pseudostrobus, P. michoacana* var. *cornuta, P. lawsonii, P. martinezii, P. teocote, P. leiophylla* y escasos *P. ayacahuite* var. *veitchii, P. montezumae y P. rudis.* Las especies principales de *Quercus* son *Q. castanea, Q. laurina, Q. rugosa, Q. obtusata, Q. crassifolia, Q. conspersa*, con dimensiones de 7-30 m. de altura. En esta vegetación se observaron dos pequeñas poblaciones de *Populus tremuloides*.

Bosque de aile-pino. Fue registrada esta comunidad, que aparentemente se encuentra en equilibrio ecológico, aunque cabe la posibilidad de que se trate de una alteración del bosque de pino-encino y con predominio actual de aile (*Alnus acuminata* ssp. *arguta*) y *Pinus pseudostrobus*. Se encuentra en laderas de cañadas, con suelos profundos.

Bosque de cedro. Superficie: 1,630 ha. Tiene escasa representación actual como bosque; se localiza en los límites de los estados de Michoacán y México, en laderas de cerros y en cañadas con poca o nula pedregosidad y rocosidad, con alturas de 15-25 m. La especie dominante es el cedro blanco (*Cupressus lindleyi*), aunque es frecuente la asociación con *Pinus pseudostrobus*. El suelo se utiliza con fines agrícolas y para pastoreo extensivo; la madera es de buena calidad para diferentes propósitos.

Bosque de oyamel. Superficie: 10,770 ha. Es bosque conspicuo de las partes altas y húmedas, tanto en laderas como en cañadas y mesetas. La especie dominante es el oyamel (*Abies religiosa*); destaca un estrato rasante que además de ser importante en la protección del suelo (Madrigal Sánchez, 1967) se explota en cierto grado para los “nacimientos” en Navidad. El *Abies* alcanza una altura aproximada de 40 m, y en ocasiones forma asociaciones con *Pinus pseudostrobus, Quercus laurina* y *Cupressus lindleyi* (Aguilar Delgado *et al*., 1983). La madera es ampliamente aprovechada y sobre los árboles de esta especie se posan principalmente las colonias de mariposa monarca (*Danaus plexippus* L.).

Bosque mesófilo de montaña. Superficie: 6,000 ha. Bosque húmedo con distribución en las cañadas más o menos profundas, representado por varias especies arbóreas, principalmente en las partes altas con bosques de pino-encino y oyamel. Las especie más comunes son *Carpinus caroliniana, Clethra mexicana, Quercus candicans, Q. acutifolia, Q. laurina, Styrax ramirezii, Meliosma dentata, Cornus disciflora, Zinowiewia concinna, Cleyera integrifolia, Symplocos citrea (S. prionophilla), Populus simaroa*. La madera de algunas especies se utiliza en pequeña escala con diferentes propósitos en forma local. Es un buen hábitat para muchas especies animales.

Bosque de galería. Se localiza a lo largo de los cauces de corrientes temporales o permanentes, con las especies *Taxodium mucronatum, Fraxinus uhdei*, *Alnus acuminata* ssp. *arguta, Salix bonplandiana* y *Acer negundo* var. *mexicanum* en la zona templada, mientras que en las partes más cálidas son comunes *Astianthus viminalis, Salix bonplandiana* y *Ficus* spp. Esta vegetación es de gran importancia para la protección de los cauces ante la erosión y como refugio de la fauna silvestre.

Factores de disturbio

El hombre es sin duda el mayor agente de alteración, directa o indirecta, con actividades que promueven cambios de uso forestal del suelo, explotaciones clandestinas, incendios y sobrepastoreo, a lo que se suman las plagas, insectos descortezadores y defoliadores, y plantas parásitas. Las consecuencias más notorias son la erosión y degradación de la cubierta vegetal y la disminución de la calidad de vida de los habitantes.

Consideraciones finales

Aunque desde el punto de vista económico y de productividad, las comunidades vegetales con mayores posibilidades son los bosques de pino-encino y de oyamel, todos lo tipos de vegetación representan posibilidades potenciales de uso múltiple sobre la base del manejo sustentable.

El bosque de cedro, el matorral de tázcate y el bosque de galería son los ecosistemas con mayores riesgos de ser alterados drásticamente, y quizá desaparecidos por los actuales agentes de perturbación. Como especies arbóreas en situación crítica de conservación están el nogalillo (*Cedrela dugesii* S. Wats), en peligro de extinción; Sabino (*Juniperus deppeana* Steud), especie rara; Pino ayacahuite (*Pinus ayacahuite* var. *veitchii* Shaw), protección especial; pino coyote (*P. martinezii* Larsen), protección especial; haya (*Populus simaroa*, Rzedowksi), especie rara; álamo (*Populus tremuloides* Michx.), especie rara; granadillo (*Platymiscium lasiocarpum* Sandw.), en peligro de extinción, de acuerdo con los criterios de la Norma Oficial Mexicana (NOM-059-ECOL. 1994) aplicada a la región.

Por localidades, para propósitos de conservación, es especialmente importante la cañada del Cinabrio, municipio de Epitacio Huerta, donde una reducida superficie de aproximadamente 1.5 km de longitud alberga cinco especies de *Pinus*, incluidas la *P. ayacahuite* va. *veitchii,* una pequeña población de *Populus tremuloides* y otras especies arbóreas.

El grado de alteración de la vegetación y otros recursos de la región otorga la mayor importancia al buen manejo de todos los ecosistemas hasta recuperar la frontera forestal que antes fue el bosque de oyamel (véase la reducción de este bosque en la figura 2).

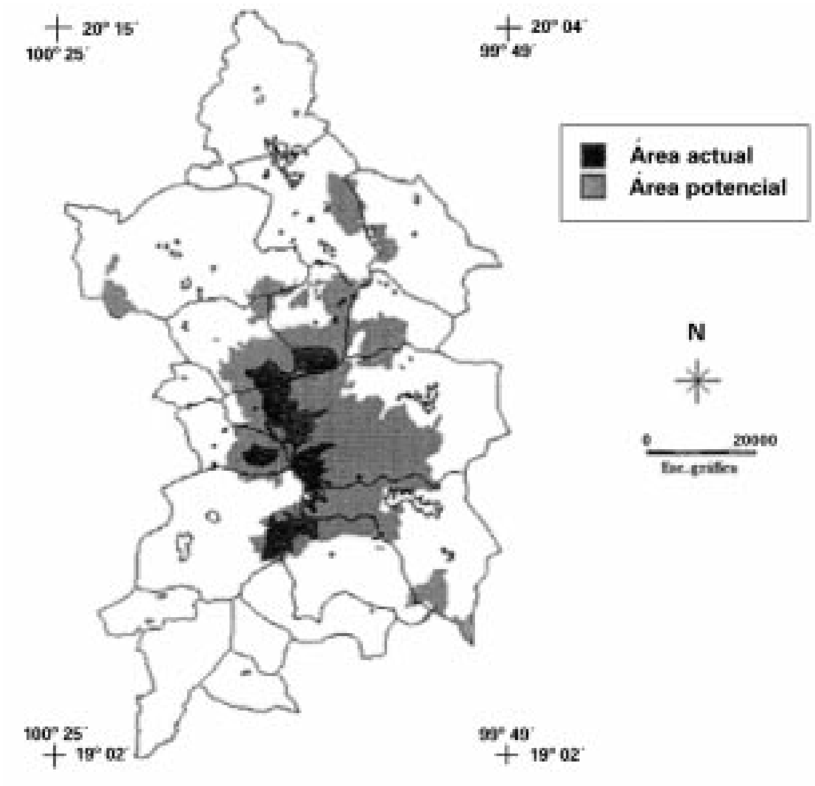

Figura 2. Bosque de oyamel: Áreas actual y potencial, Región Mariposa Monarca, México

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Round table address

Policies and Laws

by ***Brooks B. Yeager***
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The distinctive phenomenon of the trinational migration of the monarch butterfly does not fit easily under existing US domestic regimes for conservation. Currently, efforts in the US in the areas of research, monitoring, management, and public education and outreach are conducted by a variety of institutions, public and private, and include all levels of government, from local municipalities to federal agencies. The US Department of the Interior has recently prepared and published a compilation of many of such efforts, *State and Federal Monarch Activities in the United States* (October, 1997).

Although the continental-scale migration of the monarch may be subject to a number of threats, the monarch is neither endangered nor threatened as a species, nor the subject of any formal international treaty. Thus its conservation will likely remain subject to the mixed jurisdiction of states and localities. What is the appropriate role of the federal government in this context? How could federal action contribute to the coherence and effectiveness of domestic US efforts for the conservation of the monarch butterfly? Various models taken from the evolution of US wildlife conservation law and programs may be useful in this regard.

US governmental approaches to wildlife conservation (as, for example, in the area of non-game birds) commonly evolved in relation to species under severe threat. These approaches include early efforts to prohibit take, followed by the establishment of permitting regimes for incidental take (take as an indirect result of other activities), the establishment of specific legal categories and enforcement regimes for threatened and endangered species, the utilization of federal land management authorities (including the establishment of wildlife refuges in key habitat areas), the authorization of land acquisition as an instrument for habitat and species protection, the encouragement of regional and subregional planning for conservation through habitat conservation plans (HCPs), and the use of tax incentives to promote conservation.

Factors which may affect the success of monarch butterfly breeding and migration in the US, though understood in a general sense, are not well specified. Issues include the viability and conservation of California overwintering areas, the direct impact of pesticide applications and other management practices, the condition of key migration corridors and zones, the availability of food sources during migration, and the availability and quality of milkweed in broad areas under various forms of management and utilization.

The lack of a precise formulation of the conservation situation of monarchs in the US does not argue for complacency, but rather for a Federal approach designed to catalyze and encourage useful research, monitoring, management, outreach and education. The very abundance of the monarch species, and the popular understanding of the monarch migration as a spectacular and fragile biological phenomenon, offers an unusual opportunity for broad public participation in conservation action. A Federal role designed to encourage such participation could be modeled on the approach of the Fish and Wildlife Coordination Act of 1980, which authorized Federal grants for the development of plans, programs, and projects for the conservation of non-game species. Under such an authority, financial and technical support could be made available for efforts by states, localities, academic institutions, and private organizations. Such an approach could also be useful in encouraging great efforts within existing federal protected areas, such as parks and wildlife refuges, to monitor, interpret, and manage for monarchs. Under this model, an appropriate Federal agency, such as the US Fish and Wildlife Service, could assist the development of a coherent national approach to monarch conservation. However, the success of this approach would depend on the level of financial resources which could be committed. Past efforts, including those under the 1980 Act, have been hobbled by the absence of Congressional appropriations. Therefore, the level of understanding of the monarch phenomenon, and of public and Congressional support for Federal efforts to encourage monarch conservation, will be critical to the success of the approach outlined above.

Capítulo/Chapter 3

Sustentabilidad y desarrollo
Sustainability and Development

Julia Carabias
"Mucha investigación ha sido realizada, la mayoría sobre la biología de la monarca y sobre México... pero la investigación que falta es aquella que nos permita entender la interacción entre la mariposa, el bosque y el ser humano. No podemos limitar la investigación a la biología de la monarca."

David Gauthier
"Private land stewardships are very important parts of Protected Area programs. It is not that we rely solely on governments, or that we should, to achieve protection objectives. This is where working with communities and people at the local level, in what I call working landscapes, allows you to achieve protection at the same time as you work to protect your lifestyle.

Steve Malcolm
"Mission Statement of the NACMB: to achieve sustainable conservation of the monarch butterfly, monarch breeding habitat, migratory habitat and overwintering habitat in North America within sociological, economic, political, legislative and environmental realities."

Introducción

por ***Leticia Merino***
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El movimiento migratorio de las mariposas monarca a lo largo de América del Norte constituye un fenómeno extraordinario y complejo cuyo misterio y belleza no puede sino inspirar asombro y admiración. Sin embargo, este milagro repetido una y otra vez durante miles de años enfrenta hoy múltiples y diversos problemas. Pese a los grandes esfuerzos y recursos de las comunidades conservacionistas y científicas, los peligros persisten.

Como es el caso de muchas especies silvestres y fenómenos naturales en peligro de extinción, la migración de las mariposas monarca está amenazada por la destrucción de sus hábitats perpetrada por las actividades humanas. Por tratarse de una especie migratoria y a la luz de que los procesos de deterioro ambiental se presentan en diversos lugares y en distintos ecosistemas en los tres países de América del Norte, la conservación de la especie representa un desafío tanto más grande. Las monarca migratorias encaran los siguientes peligros: desaparición de los bosques del área costera central de California; destrucción de las praderas del sur de Canadá y el norte de Estados Unidos; uso intensivo de insecticidas en la agricultura en el medio oeste, y degradación de los bosques a lo largo de la cordillera neovolcánica en el centro de México. Cada uno de estos procesos se manifiesta en diversos ámbitos económicos, sociales e institucionales y obedece a las condiciones de cada lugar. La modificación de estas situaciones y los trastornos de estos procesos implican la confrontación de instituciones, de los patrones de producción establecidos y de intereses particulares.

A la luz de la gran concentración de las monarca en el área de invernación mexicana y la profunda fragilidad a la que ello las expone, muchos consideran las presiones sufridas en estos hábitats de invernación como el peligro más inminente y tal vez el más perverso para la preservación del fenómeno migratorio de las monarca. La desaparición de la mayor parte de los bosques de la costa central de California y la drástica reducción de la presencia de las monarca en esa zona demuestran lo que puede ocurrir a los grupos que siguen la ruta central de migración en América del Norte si no se detiene el deterioro forestal en México. En afanosa búsqueda de una solución, hace diez años el gobierno de México decretó la creación de la Reserva Especial de la Biosfera Mariposa Monarca (REBMM), que comprende una superficie relativamente grande en la que se han suspendido del todo las actividades productivas.

Sin embargo, los bosques de las regiones de invernación de México padecen presiones similares a las que encaran los de otras regiones del país a raíz de decenios de política forestal errática, de concesiones y prohibiciones que han impedido la valorización del bosque en términos sociales y de mercado. Estas presiones son también consecuencia del abandono y la marginación en que la sociedad rural ha vivido durante muchos años en México. Estas condiciones han limitado el interés de los campesinos en la preservación de largo plazo de los recursos forestales. A los campesinos también los han irritado las restricciones impuestas en el uso de los bosques a raíz del decreto que creó la reserva. Esta combinación ha generado periódicamente condiciones adversas para la conservación. En muchos casos, las prohibiciones de acceso a los recursos forestales, puesto que invalidan los mecanismos de control de la comunidad sobre estos recursos, han creado situaciones de "libre acceso" sin mecanismos de regulación suficientes o eficaces.

El poco éxito obtenido por la mayor parte de los esfuerzos de preservación de los hábitats de estas mariposas demuestra que las estrategias de conservación se deben basar en una comprensión más integral del fenómeno. Para empezar será preciso reconocer las condiciones y los problemas de cada región y considerar las opiniones de los diversos actores afectados. En reconocimiento de la complejidad y el carácter trinacional del proceso, la Reunión de América del Norte sobre la Mariposa Monarca se orientó a analizar los diversos problemas mencionados en el marco de múltiples disciplinas y diversos puntos de vista. La importancia y éxito de esta reunión fue que se constituyó en un foro para el comienzo de un diálogo entre campesinos, conservacionistas y especialistas en la biología y la ecología de las mariposas monarca de diversas partes del subcontinente.

Uno de los temas de la reunión fue la sustentabilidad y el desarrollo; en particular, los actuales aspectos sociales de los procesos de deterioro de los ecosistemas y la conservación en las áreas de migración de las mariposas monarca. Las presentaciones de esta sección fueron trascendentes y diversas. Sin embargo, la mayor parte de los trabajos se refirió a las condiciones sociales de las regiones de México en que se encuentran los hábitats adonde las monarca sobreviven al invierno. Las reflexiones en torno de los factores sociales que afectan el fenómeno en Canadá y Estados Unidos fueron notablemente escasas. Si se tiene la impresión de que las condiciones sociales en México son las únicas que afectan la actividad migratoria de las monarca o si se considera a las comunidades pobres responsables exclusivas de los peligros que enfrenta la migración de las monarca, entonces se tendrá una comprensión desviada y desequilibrada del desafío que entraña la conservación del fenómeno. Esta comprensión distorsionada de los retos que encara la monarca en su emigración puede convertirse en un elemento en contra de su conservación. Las ponencias presentadas en esta sección arrojan luz sobre algunos aspectos y ponen en tela de juicio las áreas relacionadas con la fase migratoria de las monarca. Se pueden agrupar en dos temas principales: 1) retos socioeconómicos, y 2) condiciones ecológicas de los hábitats de las monarca, incluidas algunas propuestas para el manejo de la conservación de los recursos naturales en esas áreas. Componen el primer tema los trabajos de Aiken, Aureoles, Bernal y Camacho, Merino, Sigala, Tapia, Treviño y Tagle. El segundo lo abordan Caro, Illsley, Johnson, Gómez-Tagle y Chávez-Huerta, Masera *et al*., Rashin *et al*., y Wagner.

La riqueza de esta reunión se refleja sólo parcialmente en este resumen. Con todo, esperamos que ayude a tender los puentes de comunicación y los compromisos conjuntos que una estrategia para la conservación exige.

Introduction

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The migration of the monarch butterfly across North America constitutes an extraordinary and complex phenomenon whose mystery and beauty cannot but inspire wonder and amazement. However, the success that has repeated itself one and another time, for thousands of years, today encounters many different threats. In spite of the fact that the conservation and scientific communities have expended great efforts and resources, these dangers have not been eliminated.

As is the case with many endangered wild species and natural phenomena, the monarch butterflies' migration is threatened due to the destruction of its habitats from human activities. And, because it is a migratory species, and the processes of environmental deterioration present themselves in different places and in different ecosystems in the three countries of North America, conservation of the species is that much more challenging. Migrating monarchs face dangers which include: the disappearance of the forests of California's central coastal area; the destruction of the prairies in southern Canada and the northern United States; the intensive use of insecticides in farming in the Mid-west; and the degradation of the forests along the neo-volcanic ridge in central Mexico. Each one of these processes presents itself in different economic, social and institutional contexts and is guided by particular conditions. The modification of these situations and the reversal of these processes imply the confrontation of institutions, established production patterns and concrete interests.

Given the great concentration of monarchs that congregate in the Mexican overwintering area, and the dramatic fragility to which these monarchs are thus exposed, many see the pressures from which this overwintering habitat suffers as the most obvious danger, and perhaps the most detrimental for the preservation of the monarch's migration. The disappearance of the major part of the forests of the California central coast and the drastic reduction of the presence of monarch butterflies there, demonstrates what can happen to the groups of monarchs that follow the central migration route of North America if the forest deterioration in Mexico is not halted. Eager to obtain success, ten years ago the Mexican government decreed the creation of a Reserve—the Special Biosphere Reserve for the Monarch Butterfly (REBMM)—where productive activities have been completely suspended on a relatively large portion of the land.

The forests of the overwintering regions in Mexico, however, suffer from pressures similar to those faced in the forests of other regions of the country. They have resulted from decades of erratic forest policies of concessions and bans that have impeded the valorization of the forest in market and social terms. These pressures are also a consequence of the abandonment and marginalization in which the rural society has lived for many years in Mexico. These conditions have limited *campesino* interest in the long-term preservation of their forest resources. The *campesinos* have also been exasperated by the restrictions on the use of the forest imposed by the decree of the REBMM. This combination has periodically created adverse conditions for conservation. In many cases, the bans on access to forest resources, while invalidating the mechanisms of community control over forest resources, have created situations of "open access" with insufficient or ineffective mechanisms of regulation of access to natural resources.

The little success obtained by the majority of the preservation efforts of the habitats of these butterflies, demonstrate that the strategies of conservation should be based on a more integrated comprehension of the phenomenon than has been done previously. To start, it will require the recognition of conditions and problems of the regions, and the consideration of the perspectives of the diverse actors involved. Recognizing the complexity and the tri-national character of the process, the North American Conference on the Monarch Butterfly was held to analyze the different problems mentioned, from distinct disciplines and points of view. The importance and success of this meeting was that it provided a forum for the inauguration of a dialogue between *campesinos*, conservationists and the specialists in the biology and ecology of the monarch, from different places on the North American continent.

One of the themes of the meeting was that of sustainability and development; in particular, the social aspects at work in the processes of ecosystem deterioration and conservation in the areas of monarch migration. The contributions in this section of presentations were significant and diverse. However, the majority of the works refer to the social conditions of the monarch's overwintering habitat region in Mexico. Reflections on the social factors that affect this phenomenon in the United States and Canada were notably poor in number. If only the social conditions in Mexico are seen as affecting the monarch migration or if exclusively the poor communities are considered directly responsible for the dangers which confront the migration of the monarch, a biased and unbalanced understanding of the challenges involved in the conservation of the phenomenon will result. This unbalanced understanding of the challenges confronting monarchs and their migration may work against actions taken to conserve them.

The papers presented in this section attempt to shed light on some aspects and challenges the areas involved in the monarchs' migration face. They can be categorized under two main themes: (1) socio-economic challenges; and (2) ecological conditions of the monarchs' habitat, including some proposals for conservation management of natural resources in these areas. Within the first theme, we have works from Aiken, Aureoles, Bernal and Camacho, Merino, Sigala, Tapia, Treviño and Tagle. Addressing the second theme are the presentations of Caro, Illsley, Johnson, Gómez-Tagle and Chavez-Huerta, Masera et al., Rashin et al. and Wagner.

The richness of this meeting is reflected only partially by this summary. We hope that it will serve to help in the construction of bridges of communication and joint commitments a strategy for conservation requires.

Round table address

Conservation and sustainable development: Confronting the contradictions

by ***Robert Aiken***
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First of all, I would like to take this opportunity to express my thanks to the Commission for Environmental Cooperation for inviting me to participate in this round-table discussion. Let me make it clear, however, that I am not an expert on the monarch butterfly — or on Mexico, for that matter. My credentials, if I can put the matter that way, derive from a long-standing interest in tropical forests and conservation issues in South-east Asia, especially Malaysia; and I teach a course on sustainable development.

I would like to focus on what I see as certain fundamental *contradictions* in how we perceive and think about nature, sustainable development, and conservation. In particular, I want to draw attention to these contradictions in the context of the lopsided nature of the global economy — i.e., in the context of the division of the world between North and South, developed and developing societies, rich and poor. I strongly believe that the fate of the monarch butterfly, and of much else besides, depends on whether these contradictions can be resolved.

On the nature of nature

Images of nature often conflict. The anthropologist, Mary Douglas (1992), has drawn attention to what she calls "nature myths." Here, briefly, are three of these myths:

i. Some observers see natural systems as resilient, as being little affected even by powerful shocks.
ii. Others see these systems as inherently fragile and likely to react sharply even to mild pressures.
iii. Yet others see these same systems as capricious and largely unpredictable.

The first of these nature myths evokes little need for restraint in exploiting and altering the environment; the second evinces a need for caution to avoid disaster; and the third displays a fatalism that sees concern and regulation as futile. These contrasting nature myths, as Douglas notes, reflect different social bases. For example, the view of nature as resilient reflects a relatively unconstrained and entrepreneurial culture, that of nature as extremely fragile, an egalitarian culture. Note that "the same scientific data about what is occurring now will suggest different futures and different courses of action when interpreted through such different world views" (Meyer and Turner 1995: 313–314).

Different views of how nature actually functions and changes tend to co-exist and to make rather incompatible bedfellows. On the one hand, a good many educated laypersons, certain social scientists and perhaps most politicians and decision makers continue to believe in the essential orderliness and predictability of nature; that is, they believe that nature, when left free of human interference, eventually attains a state of balance and equilibrium.

On the other hand, few ecologists would defend these notions. Rather, they assert that nature is inherently disorderly and largely unpredictable, that it is characterized by chaos, flux, and continual disturbance. In short, change appears to be intrinsic and natural at many different scales of time and space in the biosphere (see, e.g., Botkin 1990). Both views have major but contradictory implications for conservation and sustainable development.

The first view, that of the apparent orderliness of nature, suggests that conservation and sustainability are matters of accommodating the human economy to the constancy of nature. The second view, that of the apparent disorderliness of nature, seems to me to pose a big problem, in the following sense: What do conservation and sustainability mean in a world subject to so much disturbance and chaos — in a world, that is, where nature is as unstable as the human scene? (Worster 1993). Some species, of course, thrive on disturbance. The monarch butterfly is one example. But how much disturbance can it tolerate, either from human or natural processes, or, more likely, from a combination of the two?

Sustainable development

A widely quoted definition of the concept states that it is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987:43). Another definition states that it "is about meeting human needs, or maintaining economic growth, or conserving natural capital, or about all three" (Redclift 1991:37).

In recent years, the idea of sustainable development has taken on a life of its own and it has, among other things, become the trademark or slogan of international organizations dedicated to achieving environmentally benign development. However, many things about the concept remain uncertain. What is to be sustained? Social (sometimes called moral) capital, economic capital, human-made capital, environmental capital, or all four? For how long? What scale of activities is implied?

Neither "sustainable" nor "development" is easy to define as either an independent variable or a dependent variable. Neither, at least at this time, can be used as a firm basis for either theory or action. What we find, as one author has put it, is that the concept has "become a screen behind which resources are being allocated and decisions made, regardless of whether the forcing term is understood or not" (Wilbanks 1994:541).

A point that is not always appreciated, perhaps especially by natural scientists, is that the concept is fundamentally political. Its realization lies in answers to such questions as who is in control, who sets agendas, who allocates resources, who mediates disputes, who sets the rules of the game, how is the relationship between knowledge and power defined, whose knowledge will be drawn upon — Western scientific knowledge or indigenous knowledge of small-scale societies (Feyerabend 1987).

I don't intend to discuss the various meanings that have been attached to the concept of sustainable development in the literature of different disciplines (see, e.g., Lélé 1991; Redclift 1992; Henderson 1994; Jacob 1994; Barrow 1995). Rather, I want to draw attention to certain contrasts and contradictions that soon become evident when the concept is discussed (Redclift 1987). I will do this in a North/South context because, first of all, the salient contrast in the world today (now that the Cold War is over) is between the developed North and the developing South or between what Levi-Strauss (1966) called "hot" and "cold" societies (the former being the industrialized ones and the latter those that were colonized by the West); and second, because any discussion of the fate of the monarch butterfly must, I believe, pay particular attention to this context.

It is possible, I think, to identify at least two contrasting perspectives on sustainable development. First, there are those who argue that economic growth is the only solution to problems of environmental degradation, poverty, and human progress in the South. This is the view expressed by the World Commission on Environment and Development in its now famous report, *Our Common Future* (WCED 1987). Second, there are those who are at pains to point out that economic growth itself carries major implications for nature, thereby implying that we should examine the ends as well as the means of development. This is the view of those who subscribe to what is sometimes called "eco-development".

When it comes to looking at the origins of development problems, there is, not surprisingly, a similar lack of congruence between the two sides. Those who favour growth claim that resources in the form of money, technology and the benefits of free-trade agreements like NAFTA will flow from North to South, creating prosperity and well-being. On the other hand, the perspective of eco-development suggests that Western-style development, which reflects uneven trade and power relations, has created the problems of poverty and environmental degradation in the first place (Borgström 1997). Consider NAFTA again. The eco-development supporters argue that, among other things, the reforms implemented under the agreement could force millions of additional Mexicans off their land as agricultural price supports are phased out. In addition, they argue that NAFTA will make Mexico's forestry sector uncompetitive, with the result that extensive areas of forest may be converted to crops and pastureland. Mexico, it should be kept in mind, already has one of the highest rates of deforestation in the world (World Bank 1995).

The point I want to underscore is this: Any consideration of sustainable development within a North / South context or framework requires that we pay attention to the contradictions imposed by the structural inequalities of the global economy. In short, the limits of sustainablility have structural as well as natural origins (Redclift 1987).

Sustainable development cannot become a reality unless priority is given to improving the livelihoods of the poor. But here again we face a contradiction. How can sustainable development be achieved at the local level — for example, in the area near here where the monarch butterfly overwinters — while the effects of international development (including the various ramifications of NAFTA) continue to systematically marginalize those livelihoods? As Redclift (1987: 36) notes, the "political aspects of development extend to sustainable development options which can only be achieved through political changes at the local, national and international level". And, as he points out elsewhere, it "is an illusion to believe that environmental objectives are other than political, or other than redistributive" (Redclift 1984: 130).

Conservation

There can be no sustainable development without environmental or ecological sustainability, the main goal of which is usually defined as the maintenance of life-support systems or, in short, "natural capital" (see, e.g., Goodland 1995). Conservation focuses not only on protecting species, ecosystems and the processes that operate in nature but also seeks to improve human welfare — or at least it ought to. These two components of conservation — let's call them "biophysical" and "social" — are not mutually exclusive. In conservation planning and management, however, they are often viewed as not only separate but also competing. Typically, the biophysical component garners the larger share of the conservation budget, while the social component, as one experienced observer put it, is "usually accompanied by appropriate rhetoric exhorting all concerned to uphold the virtues of consulting with local people" (Bailey 1997:321). As the same observer has noted, the "ultimate goals of conservation efforts may be driven primarily by biological theory and ecological research, but the process by which conservation is achieved is overwhelmingly social and political. It has little to do with biology" (p. 321). (And here, no doubt, I should add that no disrespect for biology is intended by the inclusion of that last comment.)

Interpretations of conservation and environmental management tend to differ significantly between North and South, and it should be kept in mind that not all peoples share a "conservation ethic" in the Western sense of that term. Take the example of wilderness. In countries like the United States and Canada wilderness is often valued for its own sake or because it has amenity value. The situation in most developing countries is quite different. In the South, the environment, including wilderness, is a contested domain "because it is the sphere in which value is created through the application of human labour to nature" (Redclift 1987:200). Most local people probably want to protect whatever wilderness is left, but not for amenity reasons or wildlife biology. Rather, they view wilderness as a resource to be exploited, and they want the resource to be protected so they can continue to exploit it.

Poor people impose excessive strains on the environment because, among other things, of the structural demands imposed on them. An interest in conservation among the poor is likely to emerge only in the larger context of basic needs.

What are some of the main lessons that have been learned about conservation in the South in recent times? I would like to list just a few of those that strike me as particularly important in the present context:

- active support and participation by local people is crucial to the success of any project;
- efforts need to be made to ensure that *in situ* programmes strengthen local livelihoods;
- local knowledge, beliefs, values, practices and institutions often provide a better foundation for protected-area management than do plans devised and administered solely by outsiders;
- conservationists should consult at the earliest stage of a project with people who are already experienced with local cultures and social institutions;
- people's concerns should be addressed at the most effective level of social and political organization;
- most, if not all, top-down conservation strategies fail;

- conservation agencies and funding organizations should encourage projects that are designed to be fluid and adaptable, that is, they should adopt a learning-process model;
- recognition and protection of local communities' customary rights and access to lands and forests is central to any successful policy;
- in the case of biosphere reserves, secure and exclusive territorial rights over buffer zones should be granted to local communities that depend on such areas for their livelihoods; and
- more attention should be given to co-management strategies such as those implemented, for example, in Australia and Canada in recent years.

As we move into the new millennium, can the reign of *Homo economicus* be nudged aside by that of *Homo sustinens*? I hope so.

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Reserva Especial de la Biosfera Mariposa Monarca: problemática general de la región

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Caracterización general[1]

La migración de las mariposas monarca

Hasta ahora la mariposa monarca (*Danaus plexippus*) es considerada por los especialistas como una especie exitosa. Presenta una amplia distribución geográfica en el norte del continente americano y ha conquistado incluso otros territorios en las islas Canarias y Azores, así como en Australia y en el sudeste asiático, sitios adonde ha llegado gracias a la dispersión vía barcos mercantes. Especie que puede desplazarse hasta 120 km por día, merced a su amplia tolerancia a diversos ambientes se le encuentra en un rango altitudinal que va desde el nivel del mar hasta los 2,700 m (De la Maza, 1995). La migración de la población norteamericana se desencadena por la reducción del periodo de duración de la luz solar en el hemisferio norte, a partir de septiembre, así como por la progresiva presencia de masas de aire polar que disminuyen la temperatura e impiden el crecimiento de las plantas de las que se alimentan las larvas. Su movimiento migratorio se realiza durante el día y sigue las corrientes de aire ascendentes para ahorrar energía durante el traslado.

Tres son las rutas migratorias principales:

a. La de las poblaciones ubicadas al este de las montañas Rocallosas y los Grandes Lagos que se mueven hacia el suroeste y, desde fines de septiembre, ingresan a México por Tamaulipas, Nuevo León y el este de Coahuila, siguen un tramo de la sierra Madre Oriental, dirigiéndose luego a la sierra de Álvarez en San Luis Potosí, San Luis de la Paz y Querétaro, por donde ingresan al altiplano hacia la segunda quincena de octubre. De ahí la ruta se dirige hacia el suroeste y en los primeros días de noviembre se les encuentra en las tierras de los municipios de Amealco, en el estado de Querétaro, y Temascalcingo, en el estado de México. Entre la primera y la tercera semanas de noviembre se empiezan a agrupar en pequeñas colonias y a acercarse a sus sitios de invernación en los bosques de los estados de Michoacán y México.
b. Las poblaciones de mariposas que habitan en el oeste de las Rocallosas realizan un viaje mucho más corto hacia el estado de California, y se asientan durante el invierno en la península de Monterrey (Pacific Grove) y cerca de Santa Cruz en Natural Bridges.
c. Las poblaciones ubicadas entre los Grandes Lagos y la costa del Atlántico siguen una ruta “aberrante”, en vuelo norte-sur, que atraviesa las Carolinas hacia Florida y cruza el Golfo de México, aparentemente en dirección a Cuba. Su destino de invernación es aún desconocido.

La invernación de las colonias en México

En México los sitios de invernación permanente se ubican en los parajes conocidos como Cerro Altamirano (municipio de Contepec, en el estado de Michoacán, y de Temascalcingo, en el estado de México), Cerro Pelón (municipios de San Felipe del Progreso y Donato Guerra en el estado de México, y Zitácuaro en el estado de Michoacán), Cerro Chivatí-Huacal (municipios de Zitácuaro y Angangueo en Michoacán), Cerro del Campanario (municipio de Angangueo y Ocampo en Michoacán), Sierra Chincua (municipios de Aporo y Senguio en Michoacán), la Herradura (municipio de Valle de Bravo, estado de México) y el Cerro de las Palomas (municipio de Amanalco de Becerra, estado de México). Se han encontrado también otros sitios en

[1] Estas páginas representan una síntesis de trabajos sobre la región realizados por la autora en otros momentos. En este sentido, ella retoma aquí las contribuciones que a esos trabajos hicieron José Luis Betancourt, Rosendo Caro, Patricia Gérez, Caty Illsley, Guillermo Naranjo, Fernando Rosete y Tajín Villagómez.

las cercanías del volcán Popocatépetl y al sur del volcán Nevado de Toluca. Además de estos sitios es muy probable que en los próximos años se ubiquen otros refugios de las monarca. Hasta 1996 se habían registrado 20 sitios de invernación de la mariposa, once de los cuales se encontraban dentro de la Reserva Especial de la Biosfera Mariposa Monarca. De éstos, cinco están incluidos en las zonas núcelo y seis se localizan en las zonas de amortiguamiento. Todos estos sitios se ubican en bosques de oyamel (*Abies religiosa*) tanto cerrados como en regeneración, más abiertos y con presencia de un sotobosque abundante con varias especies de *Senecio* y *Eupatorium*. Sin embargo, se ha determinado que algunas de las condiciones ambientales de los bosques cerrados, como la mayor humedad relativa y la estabilidad de la temperatura, son factores determinantes para la sobrevivencia de las colonias de mariposas.

Las poblaciones que llegan a invernar a estos refugios no salen de un radio de más de dos kilómetros. Cada refugio puede tener entre siete y 20 millones de mariposas. Las colonias de invernación en México son las mayores congregaciones conocidas, ya que las de California agrupan entre 100,000 y 40,000 ejemplares. Los grupos de mariposas se posan en la parte media de los árboles, donde se protegen del viento y de las bajas temperaturas del suelo. Adheridas al tronco en grupos compactos evitan la pérdida de calor corporal. En los días soleados, las mariposas ubicadas en las partes externas del grupo reciben el calor del sol y a media mañana (a partir de las 10:30) empiezan a volar, unas, hacia las playas lodosas en busca de los arroyos y, otras, en procuración del néctar producido por las flores de *Senecio, Eupatorium* y otras compuestas. Poco después del medio día comienza el reflujo, que termina alrededor de las cinco de la tarde cuando se vuelven a acomodar antes de que la temperatura descienda a niveles críticos.

Cada invierno las masas de aire polar azotan varias veces los refugios. El viento, la lluvia y las nevadas provocan la caída de ramas y de grupos de mariposas al suelo. Las más fuertes se salvarán del congelamiento al trepar a las hierbas y arbustos del sotobosque. Muchas más mueren sepultadas por la nieve, arrastradas por el agua o congeladas con la escarcha de la madrugada. En los años extremadamente secos se les ha observado desplazarse hacia las zonas más protegidas y oscuras de las cañadas, donde la humedad ambiental las protege de la deshidratación. Además de estas causas de muerte, las mariposas son atacadas por depredadores —aves, principalmente—, así como por pequeños mamíferos, arañas y otros insectos. Se ha estimado que el 56% de las colonias sobrevive a la invernación, aunque la tasa de sobrevivencia varía de acuerdo con las condiciones climáticas de cada año. Al estudiar las características de 30 colonias, Calvert y Brower (1986) encontraron una fuerte variación de la extensión ocupada por las colonias durante el periodo invernal. El rango registrado varía entre 0.10 hectáreas (ha) al iniciarse la invernación hasta 3.34 ha hacia su conclusión. La extensión más común es de 2 ha para cada colonia. Las colonias se establecen siempre en zonas con fuertes pendientes y en las cañadas, frecuentemente con una orientación sur-suroeste, a una distancia no mayor a 1 km de alguna fuente de agua. De la Maza (1995) considera que el área mínima de protección que garantiza la sobrevivencia de las colonias es de 10 km^2, lo que debiera corresponder a una “zona núcleo” en el actual esquema de la REBMM, donde no deben permitirse actividades agrícolas, ganaderas o forestales, ni apertura de caminos o instalación de ningún tipo de infraestructura. Esta área debería estar rodeada de una “zona de amortiguamiento” que permita cubrir las posibles fluctuaciones en las áreas de ubicación de las colonias, donde se asegure la existencia de recursos alimenticios y agua suficientes. Considera que en esta zona podría establecerse un aprovechamiento forestal de bajo impacto, que mantenga en el bosque una densidad mínima de 400 árboles maduros por hectárea, pero evitando definitivamente las actividades agrícolas y ganaderas.

Varios estudios muestran que cuando la densidad del arbolado es menor a los 400 ejemplares por hectárea, la temperatura interna del bosque disminuye hasta alcanzar el umbral crítico para la sobrevivencia de las mariposas. La presencia de árboles adultos es tambien fundamental, puesto que presentan una mayor superficie de percheo libre de heladas y porque las mariposas se ubican en el nivel medio del follaje a fin de resistir las bajas temperaturas y sus consecuencias.

La región de la Reserva Especial de la Biosfera Mariposa Monarca

En términos ambientales, esta región, ubicada en el Eje Transversal Neovolcánico, se caracteriza por un relieve muy variado y accidentado, con alturas del terreno que corresponden a un intervalo de entre 2,300 y 3,600 msnm. Los suelos predominantes son andozoles (de origen volcánico), aunque también se encuentran acrizoles y luvisoles. La vegetación más importante es el bosque, con distintos ecosistemas forestales: bosques con asociaciones de pino-encino y con presencia de otras especies latifoliadas en las partes más bajas; bosques de pino, y bosques con asociación de pino-oyamel. En la actualidad los distintos tipos de bosque se hallan muy deteriorados y muchas áreas antes forestadas fueron desmontadas y sustituidas por cultivos agrícolas de subsistencia —aun en zonas de fuerte pendiente.

En términos sociodemográficos, la región soporta una elevada densidad poblacional, fuertes niveles de pobreza y altas tasas de emigración. En el territorio de la REBMM participan diez municipios, cuya población conjunta era de 494,920 habitantes en 1990.[2] Es ésta una zona de fuerte expulsión poblacional, de modo que entre 1960 y 1990 el crecimiento de la población en la zona de la reserva fue menor al que durante el mismo periodo presentaron los estados de México y Michoacán.

El crecimiento de la población (alrededor del 2% anual) del conjunto de la región puede considerarse moderado en el contexto mexicano, ya que aunque las tasas de natalidad son elevadas[3] se estima que al menos 50% de los hombres y mujeres jóvenes de las comunidades y ejidos en los que se ubica la REBMM abandonan definitivamente la región en busca de los empleos que no existen en sus pueblos (Barkin y Chapela, 1995). Muchos otros se ocupan temporalmente fuera de la región, mientras sus familias continúan habitando allí y desarrollando algunas actividades productivas. La Ciudad de México es el destino principal de los migrantes. En los últimos años, los procesos de recesión y crisis económica han afectado algunas de las ramas productivas en que tradicionalmente se ocupan estos trabajadores migrantes, como es el caso de la construcción. La clausura de empleos urbanos representa un riesgo más de incremento de la presión sobre los de por sí deteriorados recursos naturales de esta región.

Aunque las densidades de población son muy altas en la región, desde hace décadas, debido en gran parte a la emigración, las tasas de crecimiento demográfico ha empezado a disminuir. En este contexto, aunque las altas tasas de natalidad (asociadas aún a elevadas tasas de mortalidad infantil) puedan relacionarse con incrementos potenciales en la presión sobre los recursos, en la actualidad representan fundamentalmente un factor que deteriora la calidad de vida de las mujeres, cuyas condiciones de pobreza son generalmente extremas.

En cuanto a la pertenencia étnica de la población, junto a los ejidos mestizos encontramos una importante presencia de comunidades indígenas mazahuas: principalmente al sur de la REBMM, en los santuarios Cerro Pelón y Chivatí-Huacal. Dentro de la región, éstas tienden a distinguirse como las zonas de mayor densidad poblacional, y de niveles de pobreza y deterioro ambiental más acuciantes.

La mayor parte de la población se dedica a la agricultura y a la explotación forestal, esto es, para sobrevivir depende directamente del aprovechamiento de los recursos naturales. Para la mayoría de las familias éstas son actividades económicas fundamentales, a pesar de que las remesas de los migrantes representan cada vez más el ingreso monetario esencial.

La Reserva Especial de la Biosfera Mariposa Monarca

Hemos mencionado que los especialistas no consideran a la mariposa monarca una especie amenazada ni en peligro de extinción, por lo cual no cuenta con un estatus jurídico especial que la proteja, excepto en su zona de refugio invernal. Es así como en México se han establecido dos decretos que protegen las áreas de invernación de esta especie:

- Decreto de Creación de una Reserva de Refugio de Fauna Silvestre en 1980.
- Decreto de Creación de la Reserva Especial de la Biosfera, del 9 de abril de 1986, que abarca 16,100 hectáreas en las que se asientan cinco refugios de invernación ubicados en los estados de México y Michoacán. En ambas entidades la REBMM ocupa parte de los territorios de diez municipios.

El 72% de la reserva corresponde a las zonas de amortiguamiento en las que, aunque con restricciones, se permite realizar algunas actividades productivas; en el restante 28%, donde se ubican seis zonas núcleo, las actividades productivas se han suspendido. La REBMM está conformada por cinco polígonos; cuatro corresponden a los santuarios, cercanos entre sí, de Cerro del Campanario, Sierra Chincua, Chivatí-Huacal y Cerro Pelón (cuyo territorio abarca el 50% de la reserva), y el santuario Cerro Altamirano que se localiza 50 km al

[2] El territorio del conjunto de los municipios que participan en la REBMM puede considerarse como el "área de influencia" o, en un sentido general, la región de la REBMM.

[3] El promedio de hijos sobrevivientes de más de 12 años en la región oscila entre 5.5 y 4.3.

sur de los primeros. Entre las áreas norte y sur de la REBMM encontramos diferencias tanto en el tipo de manejo de los recursos naturales cuanto en actividades económicas y nivel de presión sobre los bosques.

La superficie forestal total de la reserva es de 9,834 ha (incluida la vegetación arbustiva), de las cuales 55% son bosques densos, 28% bosques cerrados y 15% bosques abiertos.[4] El área norte de la reserva es claramente forestal: en 1986 el bosque cubría más de 50% de los territorios de 48 de las 54 comunidades incluidas en la reserva. En Cerro Altamirano la agricultura tiene prominencia, mientras que el uso forestal del suelo tiene una importancia marginal y no existen aprovechamientos forestales legales con fines comerciales. Para los bosques del área norte de la REBMM, de un elevado potencial de crecimiento, el INIFAB ha estimado incrementos anuales de 18 m^3 por hectárea.[5]

Otra característica de la reserva es el fuerte deterioro ambiental de muchas de sus zonas. Alrededor de la mitad de su extensión se encuentra en situación de riesgo ambiental debido a la presencia de desmontes en zonas de fuerte pendiente y de procesos erosivos avanzados en varias áreas. En este tipo de áreas resulta especialmente importante desarrollar medidas de conservación y recuperación ambiental. Solamente pequeñas extensiones de la reserva —e incluso sólo una proporción menor de las zonas núcleo— pueden considerarse "conservadas".[6] En su diagnóstico ecogeográfico de 1995, Fernando Rosete estima que 6.31% de la superficie de la reserva puede considerarse "conservada", 45.82 "en equilibrio", 30.43 "frágil" y 17.79% "degradada".

En 1990 la población de los ejidos y de las comunidades indígenas involucrados en la REBMM sumaba 99,390 personas. El 79% de la población habita en Michoacán y el 21% restante en el estado de México. Como en el conjunto de la región, en las comunidades de la reserva encontramos altas densidades de población que van de 230 habitantes por km^2 en el área del santuario Cerro Altamirano a 124 hab/km^2 en la del santuario Sierra Chincua.

Respecto a la tenencia de la tierra, alrededor de 86% de los terrenos de la reserva son de propiedad social, 50% corresponden a tierras ejidales y 36% a comunidades indígenas,[7] 7% son propiedad privada, 3% propiedad federal y el 3% restante corresponde a una zona en litigio entre los estados de Michoacán y México. A diferencia de lo que sucede con otras figuras de áreas naturales protegidas, la de la Reserva de la Biosfera[8] no modifica formalmente el régimen de tenencia de la tierra, de modo que al crearse la REBMM no se expropiaron terrenos ni dentro de las zonas núcleo ni en las de amortiguamiento, aunque se afectó significativamente la capacidad de control campesino sobre los recursos naturales: se les privó legalmente del acceso a los predios ubicados dentro de las zonas núcleo y se les restringió considerablemente a los de las zonas de amortiguamiento.

No todas las comunidades con terrenos dentro del área de la REBMM se han visto afectadas en la misma magnitud; algunas tienen solamente unas pocas hectáreas dentro de los límites del área, mientras que gran parte de los territorios de otras se encuentra dentro de las zonas núcleo y de amortiguamiento. El rango de este impacto es muy variable, pues encontramos desde ejidos con más de 60% de su territorio dentro de

[4] Según la clasificación de la FAO, bosque denso es aquel que tiene más del 75% de cobertura, bosque cerrado el que tiene entre 74 y 40% de cobertura y bosque abierto el que tiene menos de 40% de cobertura.

[5] Inifab estima también allí existencias reales promedio de 196.480 m^3 v.t.a. por hectárea.

[6] Ésta es una síntesis muy apretada del diagnóstico ecogeográfico que Fernando Rosete realizó en 1995 con base en la definición de medios ecodinámicos, procesos de formación del suelo y de formación del relieve. Distingue cuatro categorías: los medios conservados, que poseen una cubierta de vegetación natural permanente y densa, con procesos lentos de formación de relieve que favorecen la formación de suelo y la conservación del entorno; medios en equilibrio, en los que existe un balance en el manejo de los recursos naturales y no se presentan procesos erosivos evidentes; medios frágiles, que presentan erosión laminar o procesos incipientes de acarcavamiento y son característicos de las laderas con una cubierta vegetal permanente muy erosionada; medios degradados, que no cuentan con cubierta vegetal permanente y presentan proceso de erosión manifiesto por arroyada difusa o acarcavamiento, son zonas de aporte de materiales con procesos de desestructuración difíciles de revertir.

[7] A lo largo del texto utilizamos la categoría comunidad indígena para referirnos a la figura agraria mediante la cual el Estado mexicano reconoce los derechos de propiedad de las comunidades étnicas sobre los territorios que tradicionalmente han ocupado, mientras que ejido corresponde a los terrenos dotados por el Estado a determinados grupos campesinos. Utilizo el término comunidad para referirme a los grupos de población y sus asentamientos; puede corresponder tanto a comunidades indígenas como a ejidos.

[8] Y en consecuencia en las reservas especiales de la biosfera, ya que la única diferencia entre ambas figuras es su extensión.

las zonas núcleo,[9] hasta algunos que tienen 10% o menos de sus tierras en las zonas de amortiguamiento.[10] La actitud y las propuestas en relación con la reserva, fundamentales en la instrumentación de una estrategia de conservación-desarrollo en la región, son variables entre las distintas comunidades y ejidos y se relacionan con factores como su nivel de organización (o el deterioro organizativo), densidad de población, niveles de pobreza, diversificación productiva, tipo de uso o aprovechamiento del bosque, y otros. El grado en el que el territorio comunal se ha visto afectado por el establecimiento de la reserva es también un factor importante y un punto de partida en la planeación de esa estrategia.

Retos para los esfuerzos de conservación de los recursos

Los bosques de la región de la REBMM soportan un cúmulo de presiones diversas, entre las cuales destacan el clandestinaje forestal, la problemática de la tenencia de la tierra y el control del acceso a los recursos naturales, pobreza y falta de opciones productivas para la población, ausencia de un esquema de manejo ad cuado para la reserva y los bosques de la región, y limitaciones derivadas de políticas y acciones institucionales inadecuadas. A pesar del peso de estas distintas condiciones adversas, el interés de algunas comunidades y la extraordinaria capacidad de regeneración natural de estos bosques son los factores que han hecho posible la conservación de las extensiones forestales actuales. Ambos tipos de capacidad deben ser vistos como elementos del capital social y natural que una estrategia de conservación requiere.

La pobreza y la falta de opciones productivas

En términos generales, las condiciones en las que vive la población regional muestran la insuficiencia de los recursos productivos (escasez y pobreza de los suelos agrícolas, deterioro de los recursos forestales, etc.). Por otra parte, la presencia de industrias agropecuarias, forestales o de otro tipo es precaria. Poco después de la promulgación del decreto de creación de la REBMM, la crisis económica de las familias se agudizó con el cierre de tres empresas que representaban las principales fuentes de empleo en la región: Cariflor (productora de flores), la mina de oro de Angangueo y las tres plantas de procesamiento de madera de la Unión de Ejidos Melchor Ocampo.

El Censo de 1990 reveló que alrededor del 25% de la población económicamente activa de la región no recibe ningún ingreso monetario, mientras que 19% recibe ingresos inferiores al salario mínimo.[11] Las condiciones de ingreso son aún más bajas en Zitácuaro, municipio donde se asientan muchas de las comunidades mazahuas. La producción agrícola de las unidades domésticas es, en el 80% de los casos, insuficiente para cubrir los requerimientos de consumo de maíz de las familias a lo largo del año. El acceso a servicios básicos de agua potable y drenaje es muy deficiente y la mayoría de los pueblos no cuenta con servicios de atención a la salud.

La problemática de la tenencia de la tierra y el control de los recursos

Como se mencionó, el 86% de las tierras incluidas dentro de la REBMM son propiedad social: 50% son ejidos y 36% pertenecen a comunidades indígenas.[12] Aunque formalmente la creación de la REBMM no modifica estas condiciones de tenencia de la tierra, en los hechos ha alterado sustancialmente la estructura de control de los territorios y recursos naturales. Durante generaciones los habitantes de los pueblos de esta región presenciaron la llegada de las mariposas monarca como un elemento normal del ciclo anual. No fue sino hasta que dos grupos de científicos estadounidenses y canadienses hicieron público el descubrimiento de los refugios invernales de las mariposas cuando esas condiciones cambiaron de manera sustancial, particularmente a partir de la promulgación del decreto de 1986, que se tradujo para las comunidades en el establecimiento de fuertes restricciones en el uso de los recursos naturales, esto es, limitación de sus actividades de subistencia tradicionales.

9 Como son los casos de la exhacienda de Jesús Nazareno, Rancho Verde y Cañada Seca.

10 Como sucede con Francisco Serrato, Primera fracción de El Calabozo y Contepec.

11 Generalmente se asume el salario mínimo como el límite entre la pobreza y la pobreza extrema, aunque el Consejo Nacional de Población (1993) admite que dos salarios mínimos resultan insuficientes para cubrir la canasta básica de bienes y servicios de los hogares.

12 La REBMM se ubica en el territorio de 45 ejidos y diez comunidades indígenas.

En determinados núcleos agrarios, particularmente algunas de las grandes comunidades mazahuas del sur de la reserva, las estructuras comunitarias de control de los territorios colectivos se han deteriorado hasta casi el "acceso abierto" a los recursos del bosque, que el clandestinaje forestal facilita y multiplica.

Otro problema particular de los ejidos relacionado con la tenencia de la tierra es el del "envejecimiento" de estos núcleos agrarios, con la consecuente marginación de los jóvenes respecto de los derechos agrarios y el acceso a la tierra.[13] Aunque muchas de las familias pueden disponer de pequeñas parcelas mediante préstamos parentales, el tamaño promedio de la parcela familiar de la región es de una hectárea; 70% de los jefes de familia no tienen derechos ejidales (Merino *et al*., 1995).

El clandestinaje forestal

A diferencia de lo que sucede en otras regiones forestales del país, en esta región no ha llegado a consolidarse una tradición de aprovechamientos forestales comunitarios. Esta limitación se relaciona en gran parte con el hecho de que en muy pocas ocasiones las comunidades dueñas de los recursos han poseído el control pleno. En distintos momentos, los beneficios forestales en esta región, tanto en el estado de Michoacán como en el de México, han estado sujetos a vedas.

Paradójicamente, al cobijo de las vedas se arraigaron prácticas y redes de clandestinaje forestal. En distintas regiones y en diversos momentos, las vedas forestales en México han tenido efectos contrarios a los objetivos de conservación pretendidos. La historia forestal del país nos señala como tendencia que las zonas en que se llevaron a cabo aprovechamientos forestales regulares el deterioro de los recursos ha sido considerablemente menor al de las zonas largamente vedadas, en las que el clandestinaje y el cambio de uso del suelo han sido procesos constantes.

Durante la anualidad 1993-1994 sólo una minoría de las comunidades de la REBMM llevó a cabo aprovechamientos forestales consistentes, esto es, amparados en permisos oficiales y basados en planes de manejo forestal autorizados. Se trata de siete ejidos, de los 48 núcleos agrarios que en la región de la REBMM tienen potencial forestal. Las ganancias que esta producción generó fueron menores: en 1994 el precio de la madera fue de 158.00 pesos el metro cúbico,[14] por lo que los 24,247 m^3 que estos ejidos aprovecharon entonces les produjeron 53,825,752.00 pesos.[15] Aunque en realidad estas ganancias son reducidas, en las condiciones de precariedad de la economía regional representan para las comunidades un ingreso y un incentivo para proteger los bosques contra incendios, plagas y prácticas clandestinas. En algunos de estos ejidos los aprovechamientos forestales regulares pueden contribuir a crear las bases de esquemas de manejo de los recursos que busquen sostener la cosecha forestal y los recursos en el largo plazo.

A pesar de contar con planes de manejo y con industrias forestales, aun en estos ejidos la estabilidad de los aprovechamientos forestales legales es precaria. Las empresas campesinas enfrentan una variedad de problemas y necesidades, entre los que destacan la pobreza de las familias y sus apremiantes necesidades, la descapitalización de las empresas sociales forestales y sus problemas de comercialización. Otros factores que han bloqueado el desarrollo del manejo comunitario son las dificultades de organización interna de ejidos y comunidades y la carencia de recursos económicos para elaborar los estudios y los planes de manejo del bosque que la legislación forestal exige para aprobar aprovechamientos regulares. Nunca han contado con apoyos oficiales.

Durante la anualidad 1993-1994 se autorizó también para esta región la extracción forestal de 56,000 m^3 de madera, producto de las "limpias de monte" que se llevaron a cabo en seis comunidades indígenas. Estas limpias son comunes en la región como mecanismo para legalizar la disposición de los residuos maderables

[13] Resulta particularmente limitante el hecho de que la mayoría de los jóvenes carece de capacidad de decisión sobre el uso de los bienes de los ejidos. Esta situación se debe a que los derechos ejidales (que incluyen el acceso a la tierra y la capacidad de decisión sobre los bienes ejidales colectivos) corresponden por lo general sólo al padre de familia, que únicamente puede heredarlo a uno de sus hijos varones. En los ejidos de la REBMM, como en muchos otros en el centro de México, los titulares de los derechos ejidales son ahora hombres de avanzada edad que han dejado de participar en las actividades productivas locales, pero que conservan sin embargo una fuerte capacidad de decisión sobre éstas.

[14] El precio del dólar durante 1994 fue de alrededor de seis pesos.

[15] Cinco de estos siete ejidos cuentan con aserraderos, pero la baja agregación de valor a la producción forestal es característica de las empresas sociales en esta región. Si el total de la producción maderera mencionada se hubiera aserrado, las ganancias habrían sido 160% superiores.

del monte luego de las extracciones clandestinas de gran escala. Caro *et al*. (1995) estiman que el volumen anual de los aprovechamientos forestales clandestinos equivale a la madera de un área de 470 ha de bosque denso.

Un factor que en la región estimula permanentemente el clandestinaje es la demanda de materia prima por parte de la industria regional, cuya capacidad instalada rebasa ampliamente las posibilidades de abasto sustentable de los bosques de la región. En el área michoacana de la REBMM, la capacidad de las industrias madereras resulta siete veces mayor al volumen de madera en rollo producido por los aprovechamientos autorizados, que alcanzan a abastecer únicamente el 13% de la demanda industrial regional de materia prima. Puesto que para ninguna empresa resulta rentable operar con niveles de producción tan bajos, se puede suponer que buena parte de la materia prima que estas industrias consumen proviene del clandestinaje forestal regional.

El clandestinaje afecta negativamente a las comunidades campesinas que manejan legalmente sus bosques, ya que mantiene deprimidos los precios de la madera en la región y genera conflictos que obstaculizan la organización comunitaria interna. Los campesinos mismos estiman que los precios de la madera clandestina resultan entre 50 y 70% más bajos que los del mercado regular. El clandestinaje tiene también fuertes impactos sobre el bosque, puesto que ese tipo de extracciones generalmente rebasa la cosecha sustentable de los predios forestales, pasando por alto cualquier tipo de cuidados por la regeneración de los recursos, o los impactos ambientales que ocasionan sobre suelos, cuerpos de agua, arbolado residual y especies de flora y fauna.

En esta región, como en otras similares, la vigilancia para prevenir y sancionar la tala clandestina está a cargo de varias instituciones oficiales; sin embargo, un factor determinante para la vigilancia exitosa es el interés de los propios campesinos en proteger y conservar sus recursos, así como la conveniencia que observen en el hecho de adecuarse a las condiciones impuestas en los marcos legales. En este sentido, si bien es cierto que la base de recursos forestales con que cuenta actualmente la región resulta insuficiente para mantener aprovechamientos a partir de los cuales pueda sostenerse la economía de las familias campesinas, también resulta cierto que la generación de beneficios económicos a partir del uso del bosque representa un incentivo fundamental para promover el interés campesino en su preservación y en la prevención del clandestinaje forestal.

Limitaciones institucionales y organizativas

En diversos puntos de este texto se ha señalado que un primer problema en la gestión de la reserva fue la forma en que se desarrolló, ya que aunque la Ley Forestal entonces vigente y la actual Ley General del Equilibrio Ecológico y la Protección al Ambiente conceden a los ejidos y comunidades afectadas el derecho a la información y consulta previas al establecimiento de cualquier medida que pueda afectar su acceso a los recursos forestales, la reserva se estableció sin que esto sucediera. Luego del desconcierto y confusión iniciales, la respuesta de los pobladores al establecimiento de la reserva ha sido diversa. Encontramos entre ellos una gama de actitudes que van desde el interés por la preservación del bosque, como sucede en los ejidos El Paso, Remedios y Mesas de Xoconusco, con bosques conservados e incremento de las condiciones de “acceso abierto” a los recursos que venían dándose desde tiempo atrás, particularmente entre las comunidades mazahuas, hasta los desmontes acelerados poco después del establecimiento del área protegida, como sucedió en la comunidad indígena de San Cristóbal y en el ejido Asoleadero.

La propia legislación forestal ha resultado limitada para proveer los instrumentos y esquemas jurídicos que requiere la protección de los bosques de esta región. La Ley Forestal de 1992 (vigente hasta 1997) desreguló el control sobre el transporte y la industrialización de las materias primas, limitando considerablemente la posibilidad de detener la presión sobre el bosque.[16] Otro punto de impacto negativo del actual marco legal es el de la prestación de los servicios técnicos forestales, pues las zonas de amortiguamiento se han abierto a la libre competencia entre los profesionistas forestales. Así, desde 1992 es posible para las comunidades contratar los servicios de los técnicos forestales. Sin embargo, la ley no establece las condiciones mínimas de calidad de estos servicios y los precios suelen resultar el criterio determinante para

[16] De este modo, en 1994 el 69% de las sanciones (y el 95% del volumen infraccionado) se aplicaron por ilícitos relacionados con la extracción en el monte, el 17% de las sanciones afectaron a la industria y el 14% a los transportistas. Esta ley fue derogada y la actual establece algunos controles más rígidos para estas actividades.

seleccionarlos. En la región de la REBMM, como en otras zonas forestales del país, estos cambios deterioraron la calidad de los servicios técnicos forestales, que tienden a orientarse casi exclusivamente a la extracción de madera, en detrimento de la búsqueda de la sustentabilidad de la cosecha o de la reducción de los impactos ambientales de la extracción. Para los bosques de la REBMM, dada su fragilidad ecológica, estas condiciones tienen impactos particularmente graves.

A las limitaciones mencionadas se suma la lentitud de los trámites para obtener permisos de aprovechamiento forestal, pero el asunto se torna grave en el caso de las comunidades de las áreas de amortiguamiento de la reserva, dada la mayor regulación de los aprovechamientos forestales que establece el decreto. La frecuente demora de estas gestiones se añade a la prescripción de no iniciar los aprovechamientos hasta que las mariposas hayan abandonado la región. Por eso es muy común que los trabajos de extracción se concluyan durante la temporada de lluvias, lo que incrementa considerablemente los impactos ambientales y los costos de extracción. Los retrasos en los trámites ocasionan además una tensión frecuente entre comunidades e instituciones de gobierno y tienden a favorecer el clandestinaje entre los productores siempre urgidos de ingresos económicos.

Otra limitación que ha detenido la participación de los ejidos y de las comunidades indígenas en el proyecto de la reserva ha sido la debilidad de sus organizaciones regionales. Durante los años setenta y ochenta operaron en el oriente de Michoacán dos agrupaciones regionales de productores rurales: la Unión de Ejidos Melchor Ocampo, que se articulaba en torno a los aprovechamientos y a la industrialización de la producción forestal, y la Unión de Ejidos Otomí-Mazahua. La primera organización, que llegó a incorporar 34 ejidos, contaba con tres plantas industriales y constituía una de las empresas de mayor peso económico en la región. Sin embargo, su constitución respondió más a la iniciativa de un grupo de funcionarios de gobierno que a la motivación de los ejidos asociados. Pero además en la gestión de las empresas, la capacidad de decisión de los directivos del Banco de Crédito Rural[17] fue siempre mucho mayor que la de los representantes campesinos. La Unión se desintegró en 1991, en medio del descontento de los socios, una fuerte corrupción y desastre económico. Más allá del impacto económico de la quiebra de este proyecto, en términos organizativos la consecuencia fue el recelo de los ejidatarios hacia nuevas propuestas de organización colectiva para la producción y el manejo de sus recursos naturales. La experiencia organizativa de las comunidades mazahuas ha sido aún más limitada; en tiempos recientes su organización más importante fue la Unión de Ejidos Otomí-Mazahua, promovida por el Instituto Nacional Indigenista. La actividad de esta agrupación se redujo en gran medida a la distribución de los recursos del Programa Nacional de Solidaridad en el periodo cercano a las elecciones estatales y municipales de 1990.

A partir de 1995 se conformó la Alianza de Ejidos y Comunidades de la Reserva Especial de la Biosfera de la Mariposa Monarca, que agrupa a la mayoría de los ejidos y comunidades indígenas que llevan a cabo aprovechamientos forestales regulares. Esta alianza se organizó primero en torno a demandas de mejora de las condiciones de producción forestal y ahora buena parte de su trabajo busca fortalecer la apropiación comunitaria de los procesos de producción forestal. Paulatinamente ha incorporado a su programa otras demandas relacionadas con el desarrollo y el control del ecoturismo, un mejor trato de las instituciones oficiales hacia los ejidos y el planteamiento de modificar el decreto de definición de la reserva, con énfasis en las necesidades de las comunidades y ejidos. A la fecha, la Alianza cuenta con un fuerte prestigio y capacidad de convocatoria entre muchos de los ejidos y comunidades de la reserva, y ha desarrollado también considerablemente una creciente capacidad de propuesta.

Ausencia de un esquema de manejo regional[18]

La revisión de la ubicación de las distintas zonas (núcleo y de amortiguamiento) y de los límites mismos de la REBMM constituye una primera necesidad, ya que no todos los sitios de establecimiento de colonias de mariposas reconocidos en la región se hallan dentro de las zonas núcleo, e incluso algunos se encuentran fuera de los límites de la reserva; además de que en algunas zonas núcleo no ha habido colonias de mariposas desde hace varios años.[19] Por otra parte, el esquema actual de polígonos discontinuos dificulta una perspectiva y un manejo del territorio regional como conjunto.

[17] Banca oficial de apoyo al sector rural.

[18] Al hablar de un esquema de manejo regional, no se incluye el santuario Cerro Altamirano.

[19] Es el caso de una de las dos zonas núcleo del santuario Cerro Pelón.

Para administrar los recursos con un enfoque de cuenca resulta insuficiente el manejo atomizado de los bosques de los predios (sean éstos ejidales, comunales o privados), los que —respetando las condiciones particulares de tenencia— debieran articularse en función de un esquema de ordenamiento y manejo territorial regional.

En la región encontramos distintos tipos de bosque, que presentan diversos grados de perturbación y la mayor parte de las veces requieren ser manejados no sólo con fines de aprovechamiento sino de restauración y conservación. Los bosques de *Abies*, que se encuentran por encima de la cota de los 2,000 m, y constituyen el hábitat invernal de las monarca, presentan distintos problemas. Uno es el de algunas de las zonas núcleo en las que resulta muy baja la densidad de renuevo de oyamel debido al envejecimiento de las masas forestales y a la práctica de libre pastoreo, frecuente en las áreas cercanas a los santuarios Cerro Pelón y Chivatí-Huacal.

En la actualidad, el manejo que reciben los bosques ubicados dentro de la reserva consiste en una veda total en las zonas núcleo, donde incluso las intervenciones de saneamiento forestal quedaron prohibidas. Para las zonas de amortiguamiento fue restringida la intensidad de la extracción en 20% respecto a la posibilidad que muestran los estudios dasonómicos. Estos bosques, como los ubicados en las “zonas libres” vecinas a la reserva, se manejan con acuerdo al Método Mexicano de Ordenación de Montes, orientado fundamentalmente a la extracción maderera y basado en un método de selección individual. Estas medidas se han establecido sin fundamento en estudios sobre las necesidades particulares de regeneración de los bosques de la región, específicamente los de *Abies*.

Un esquema de manejo regional de la reserva debe basarse en la comprensión de las necesidades e intereses de los habitantes, hasta ahora ignorados por el Plan de Manejo de la REBMM, que obvia cuestiones tan fundamentales en la región como el abasto de leña para uso doméstico. Actualmente este consumo en la región se aproxima a los 300,000 m^3 anuales y supera por mucho al volumen de los aprovechamientos de madera autorizados.[20] Una parte de la leña se obtiene de los residuos del aserrío y la mayor parte proviene de los restos de los aprovechamientos forestales en el monte, con lo que se reduce la existencia de materiales combustibles dentro del bosque. No obstante, la magnitud de este consumo hace necesario evaluar los impactos de esta extracción sobre el bosque tanto dentro de los santuarios de la reserva como en sus zonas aledañas.

Algunas de las limitaciones señaladas pueden resolverse si se desarrolla un esquema de manejo más detallado e integral, que considere el contexto regional y busque integrar las acciones de conservación con el mejoramiento de los aprovechamientos forestales, de las actividades agrícolas y pecuarias, así como con otras actividades de transformación que brinden opciones de empleo a los habitantes de los santuarios. En esta búsqueda de alternativas, el manejo de los recursos maderables y no maderables, los destinados al mercado y los del consumo doméstico, debe tener un lugar importante por las condiciones demográficas y de pobreza que imperan en la región. Es también muy importante que la estrategia de preservación del bosque incluya el fenómeno de la invernación de la mariposa monarca en México y busque la articulación del manejo de las zonas núcleo con el de las zonas de amortiguamiento y el de los bosques vecinos.

La conservación del fenómeno migratorio de la monarca es un problema complejo que implica mantener el hábitat invernal de esta especie, pero también enfrentar la marginación social y económica en que vive la mayoría de los habitantes de esta región. Los esfuerzos de conservación enfrentan el gran reto de crear las condiciones sociales y ecológicas que hagan posible la permanencia de estos bosques. No está de más insistir en que la participación de los pobladores de la región en el manejo de la reserva ha de ser un fundamental en estos esfuerzos de conservación.

[20] Este dato fue estimado en función de la población de la región y el cálculo de Masera (1990) sobre el consumo de leña de las familias de la zona purépecha de Michoacán.

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El sistema agrológico forestal como base para el diagnóstico-manejo forestal integrado en la reserva Chivatí-Huacal, Michoacán

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Resumen

En el invierno de 1995-1996 se realizó un diagnóstico integrado con base en el Sistema Agrológico Forestal (SAF) desarrollado en la última década por el Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP). Se aplicó en la Reserva Chivatí-Huacal Región Monarca, porción El Paso, Ocampo, Michoacán (México). Para determinar áreas y ubicación de acciones de manejo forestal sustentable, se cuantificaron, por muestreo integrado (isocrónico e isogeográfico), cobertura vegetal, suelos forestales, dasonomía y productividad natural del bosque e índice edáfico, riesgo de incendio y erosión, condiciones de hábitat y fauna, inventario de plagas e insectos dañinos, uso del suelo y condiciones socioeconómicas. Como proyectos derivados del SAF se desarrollaron diversas alternativas basadas en el potencial forestal del área. Entre éstas tenemos sistemas silvícolas de bajo impacto ecológico, cuantificación de captura de carbono por la masa arbolada, cuantificación de vegetación arbórea y vegetación riparia, tecnología para manejo de caminos y hábitat para la fauna silvestre. Finalmente se recurrió a un sistema de información geográfica (SIG) para integrar todo.

Introducción

Ejido El Paso

La porción forestal del ejido El Paso se encuentra situada inmediatamente al norte del Cerro el Huacal y al oriente del llano del Chivatí, en la región de la mariposa monarca. Su extensión es de 460.22 ha y su rango altitudinal va de 2,600 a 3,200 msnm. La población más cercana es Ocampo, Michoacán. En este ejido se realizó un aprovechamiento forestal persistente por diez años con renovación anual a partir de 1986, según autorización de la desaparecida Secretaría de Agricultura y Recursos Hidráulicos (SARH).

Dentro de estos aprovechamientos fue aplicado el Método de Desarrollo Silvícola (MDS) en las áreas libre y de amortiguamiento, con resultados muy deficientes ya que a la fecha, ocho años después, la regeneración es todavía muy precaria en las partes sometidas a este tipo de manejo.

Actualmente, los ejidatarios conscientes de la necesidad de preservar su riqueza han planteado la búsqueda de usos alternativos para no degradar su bosque en las áreas libre y de amortiguamiento y un planteamiento para manejar y mantener su área núcleo.

La dotación de tierra

En 1936 David y Cándido Soto Mora lograron, mediante gestiones, recibir de manos del General Lázaro Cárdenas la dotación de 460 ha forestales. Tiempo más tarde, en 1950, se logró el plan definitivo, un ejemplo de sustentabilidad forestal, gracias al cuidado del bosque ejercido durante 60 años. El presente estudio se realizó con el fin de llegar a obtener un conocimiento mayor, transferir tecnología, capacitar a los dueños y generar el primer bosque escuela en México. Recibió el apoyo económico de los ejidatarios, la Secretaría de Medio Ambiente, Recursos Naturales y Pesca (Semarnap), la fundación Produce-Michoacán y la tecnología del INIFAP.

Bosque El Paso, importancia y urgencias de conservación

El Paso es, entre los terrenos comunales y ejidales de la sierra y reserva Chivatí-Huacal y El Campanario, de los que escasamente han logrado sobrevivir a la intensa degradación que sufre toda el área. La relación entre la conservación de la biodiversidad, la captación del agua que nutre poblaciones aguas abajo, la estabilización de la productividad de suelos, las necesidades del ejido y la conciencia de conservar los recursos, alcanzó el equilibrio que mantiene el bosque con altos rendimientos. En este lugar fueron identificadas y clasificadas 96 especies de vegetación y 143 de fauna silvestre.

La captación hídrica provee de agua a diferentes poblaciones desde hace muchos años; dentro de los proyectos a ejecutar en 1998 se propuso uno que permitirá aplicar tecnología para mantener y conservar los manantiales y arroyos de la montaña.

La forma en que se han valorado los recursos forestales en México está muy lejos de apreciar su potencial real. Las tecnologías de inventario esencialmente maderero, el análisis y manejo forestal y la preparación de quienes los aplican, no están a la par de la complejidad de los recursos; por esta razón se desperdician tanto información como recursos económicos cuando se realizan planes de manejo. Este problema generó en el INIFAP la idea de crear un sistema de muestreo, análisis y manejo de bosques que presentará ventajas diversas e integración. Este sistema permitiría obtener muestras, al mismo tiempo y en el mismo espacio (isocrónica e isogeográficamente), de los componentes del bosque (agua, fauna silvestre y productiva, vegetación, madera, ecoturismo y recreación, silvoagricultura, plantas alimenticias y medicinales, etcétera). Los efectos de diferentes disturbios (incendios, erosión, sobrepastoreo, deforestación...) se evalúan con el muestreo, en su fase de análisis se ensamblan los datos y finalmente se les da un tratamiento mediante sistemas de información geográfica (SIG); de esta manera se pueden determinar causas y efectos con gran rapidez y precisión. También los indicadores de condición del ecosistema, denominados recientemente “indicadores de sustentabilidad”, son derivados con gran facilidad.

Tratando de unir la tecnología del SAF con el desarrollo forestal del ejido El Paso y tomando en cuenta que este ejido ha mantenido por 64 años la alta calidad de su bosque aun con fuertes presiones externas e internas, el INIFAP-Morelia decidió apoyar la realización de un estudio integrado para preservar la riqueza forestal del bosque y generar proyectos productivos para mantenerlo.

Objetivos

1. Desarrollar un diagnóstico mediante el Sistema Agrológico Forestal como base para planear el manejo sustentable de los recursos forestales de El Paso, Ocampo, Michoacán.
2. Entrenar a los ejidatarios y dueños del predio en dicho sistema de trabajo para que en poco tiempo adquirieran un conocimiento integrado de sus recursos naturales.
3. Cuantificar, de forma integrada: suelo, agua, árboles, hierbas, arbustos, fauna, dasometría, cuencas, arroyos, y riesgos de erosión e incendio.
4. Generar las bases para establecer proyectos sustentables.
5. Obtener un permiso normal de aprovechamiento forestal en áreas de amortiguamiento y libre de la reserva Chivatí-Huacal.

Metodología

Con los ejidatarios de El Paso se iniciaron los trabajos de campo mediante un premuestreo orientado a suelos, debido a que es uno de los factores más estables del ecosistema. También se aplicaron criterios estadísticos con base en la granulometría. Posteriormente, con base en el premuestreo y los datos del tamaño de la muestra, así como los del coeficiente de variación de la o las propiedades en medición, se determinó el tamaño de muestra correspondiente mediante tablas de “t” a un valor porcentual determinando. Las etapas del trabajo fueron las siguientes:

Etapa I

- Premuestreo.
- Identificación, ubicación e interpretación de sitios SAF en el área mediante análisis de aerofotografías y/o imágenes de satélite.

Etapa II

- Desarrollo de un muestreo isocrónico e isogeográfico integrado con base en los componentes suelo, dasonomía, vegetación y fauna.
- Recopilación de datos climáticos.
- Obtención y prueba de modelos.

Etapa III

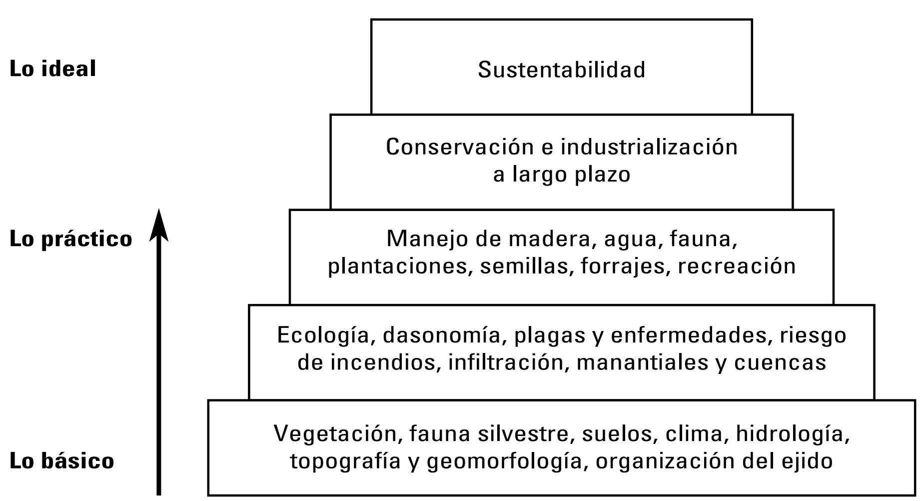
- Interacción mediante análisis multivariado.
- Integración de resultados mediante cartografía SIG.

Resultados

La sustentabilidad en este sitio se explica por el equilibrio entre el uso del bosque para la producción de madera, la conservación de la vegetación y la fauna silvestre, el grado de infiltración y alimentación de manantiales y de conservación de las áreas riparias y la productividad natural de suelos forestales. No existe erosión en el bosque, no hay proceso de sucesión secundaria y es constante el flujo de agua.

En un periodo de 90 días se obtuvo la integración de los componentes del ecosistema forestal de 460 ha. De acuerdo con la metodología del Sistema Agrológico Forestal (Gómez Tagle, 1982, 1998) se siguió el proceso que se muestra a continuación:

Integración de áreas para desarrollar el SAF



Fueron entrenados 26 ejidatarios para que conocieran a fondo la productividad natural de sus terrenos forestales. Se formaron brigadas para cada una de las actividades, de manera que en la práctica los ejidatarios muestrearon suelos forestales, vegetación arbórea, arbustos y hierbas, hojarasca, infiltración de agua en suelo de bosque, riesgo de incendio, dasometría, caminos forestales, cuencas para captación de agua y fauna silvestre.

La distribución de sitios de muestreo fue con acuerdo a las bases fisiográficas del SAF.

Se obtuvo el análisis físico-químico de 25 variedades de suelo, cuyos resultados fueron aplicados a la planeación de la producción integrada. Se clasificaron 96 especies de plantas y se encontraron 15 familias de mamíferos con 39 especies; aves, 31 familias con 99 especies; anfibios, dos familias con dos especies, y reptiles, dos familias con tres especies.

Se cuantificaron la infiltración de agua en los suelos de bosque y las cuencas que originan agua.

Se clasificaron áreas nunca aprovechadas y se determinó su potencial forestal para producir:

- Madera (mediante índice de sitio e incrementos por rodal).
- Plantaciones agroforestales (características de suelo y clima y fenología de árboles).
- Cultivos forrajeros de corte (fenología de cultivos forrajeros).
- Criaderos de fauna silvestre (el muestreo integrado de fauna y vegetación arbórea, arbustiva y herbácea).
- Semilla forestal de alta calidad (la dasometría de rodales plus).
- Cuencas de producción de agua (identificación topográfica, clasificación de canales y vegetación riparia).
- Zonas para ecoturismo y recreación (mediante medición de accesos, tipo de caminos y su mantenimiento y ubicación de infraestructura).

Conclusiones

- Se logró un conocimiento y la planeación del uso actual y potencial del terreno forestal en un tiempo muy corto, sin dejar de considerar que al mismo tiempo se entrenó al personal del ejido.
- La Reserva Chivatí-Huacal en su porción del ejido El Paso tiene excelentes características de productividad forestal natural por la conservación que los propios ejidatarios han cuidado durante 64 años.
- El sistema de trabajo aplicado permite asegurar que es posible planear y ejecutar en forma rápida (siempre que haya disposición) el manejo sustentable forestal basado en el potencial del suelo.

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El desarrollo sustentable regional y la mariposa monarca

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Introducción

Espacio físico del hombre y la mariposa monarca

El espacio que ocupa la mariposa monarca cada año en nuestro país se ubica principalmente en la parte serrana del altiplano occidental de los estados de Michoacán y México, donde desde hace miles de años este insecto invierna entre noviembre y marzo como parte de su ciclo de vida. En la zona existen vestigios de la presencia de actividades humanas desde la época prehispánica, específicamente de la cultura otomí-tarasca, pero es en los últimos 50 años cuando el tradicional equilibrio se vulnera día a día como resultado de las actividades humanas.

En una superficie aproximada de 800,000 hectáreas, donde originalmente había bosques de pino y oyamel, que reunían las condiciones ecológicas para recibir las migraciones de mariposas, sólo quedan 150,000 hectáreas de bosque discontinuo. La pérdida de la cubierta vegetal progresa geométricamente, al grado de que en los últimos 50 años se perdieron cerca de 600,000 hectáreas, lo que hace suponer que de seguir esta tendencia se habrá perdido lo que resta de este bosque en los albores del siglo XXI. En este espacio de 22 municipios se asientan 54 ejidos y comunidades indígenas, 34 de las cuales están en el estado de Michoacán y 20 en el de México. Como medida de protección del fenómeno migratorio de la monarca, en la década de los ochenta se decretó la existencia de una Área Natural Protegida en una superficie de 16,110 ha, donde actualmente viven más de 200,000 habitantes. Una buena parte de la población económicamente activa se ocupa en la agricultura y en actividades forestales. Estudios recientes refieren que 44% de la población de la zona vive en condiciones de extrema pobreza. La agricultura de autoconsumo es la actividad más extendida y el principal mecanismo de sobrevivencia, a pesar de sus bajos rendimientos. Nuestros propios estudios destacan que los productores de maíz en la zona de la reserva con los terrenos de mejor calidad recuperan en la cosecha sólo 40% de sus costos de producción, lo que señala la baja productividad de esta ocupación, sin considerar los efectos que la mayor parte de las prácticas agrícolas que allí se realizan tienen sobre la cubierta vegetal y del suelo.

La complejidad de la problemática

La desaparición acelerada de la cubierta vegetal de bosques de pino, oyamel y otras especies es el reflejo de la interacción de muchos factores y se relaciona directamente con la necesidad de la población de obtener los satisfactores elementales para la subsistencia. La situación actual de presión social y deterioro ambiental es resultado de un largo proceso de uso inadecuado de los recursos, que se relaciona con distintos aspectos de la historia de la región: desde los años de la Conquista, cuando la cultura indígena fue brutalmente desintegrada y los conquistadores introdujeron prácticas productivas radicalmente diferentes. Desde entonces y en diferentes momentos se han presentado diversos patrones de tenencia de la tierra y de aprovechamiento de los recursos naturales; un acontecimiento clave en la historia de estas tierras fue la expedición de las leyes de 1833 y 1847, desde Gómez Farías hasta las Leyes de Reforma, cuando se inició la desamortización de las tierras indígenas, catalizada por la invasión estadounidense y la expansión de las haciendas.

A lo largo de este siglo, distintas políticas promovieron un modelo de aprovechamiento forestal que buscaba fundamentalmente la mayor utilidad en el menor tiempo posible. Estas políticas favorecieron a grupos económicos ajenos a los dueños de los bosques, y las ganancias así generadas fueron siempre invertidas fuera de la región, canalizadas a otros sectores de la economía.

De este modo, la mayoría de los pobladores de la región fue marginada de los beneficios que generó la explotación de sus recursos; se clausuró durante décadas la posibilidad de que aprovecharan los bosques de forma viable en el largo plazo y en favor del desarrollo regional. Fue así como, lejos de generarse una actividad económica permanente que sirviera de base al desarrollo de los distintos sectores productivos, se produjo la destrucción de los recursos naturales, la pobreza y la marginación de los campesinos forestales.

A las consecuencias de este modelo económico se ha agregado el impacto negativo de las acciones gubernamentales a través de instituciones y programas de apoyo que han fracasado constantemente en el cumplimiento de sus objetivos. La desordenada intervención de agentes externos a las comunidades de la región ha generado más vicios y confusión que beneficios.

Los bosques de la región, condición necesaria para la presencia de la mariposa, han venido sufriendo procesos de degradación constante desde la década de los cincuenta. En un primer tiempo se vieron afectados por la acción de la veda general en el estado de Michoacán y los esquemas de aprovechamiento forestal establecidos en el estado de México, que favorecieron el clandestinaje y la ausencia de manejo forestal en la extracción. El deterioro forestal se ha visto notablemente acelerado luego de los decretos de protección de la mariposa monarca y de creación de la REBMM en 1980 y 1986, pues al afectar los aprovechamientos forestales favorecieron en los hechos la explotación desordenada y rapaz de los recursos. Finalmente estas tendencias se han visto agravadas a partir de la expedición de la ley forestal de 1992, que ha buscado dar respuesta a un esquema gubernamental de apertura económica indiscriminada luego del ingreso del país al Acuerdo General de Aranceles y Comercio (GAAT) y, particularmente, al Tratado de Libre Comercio de América del Norte (TLC). El esquema de desregulación de la ley forestal ha resultado desastroso para el sector forestal nacional; la globalización económica y el proyecto neoliberal, promovido por los gobiernos de algunos de los países más ricos de la tierra y aplicado rigurosamente por el gobierno mexicano, han tenido como consecuencia el incremento de la destrucción de los bosques, incluido el del hábitat invernal de la monarca.

La aplicación de estas políticas no sólo ha lesionado y vuelto miserables a grandes grupos de la población del país; también ha destruido y sigue destruyendo los recursos naturales al generar un círculo perverso, severamente destructivo.

En las condiciones de competencia desigual en las que México participa en el TLC, el mercado nacional ha sido invadido por productos forestales de bajo precio (a menudo debido a la presencia de subsidios encubiertos). Con una normatividad ampliamente desregulada, se crearon las condiciones para obtener productos forestales básicamente maderables en forma ilegal, pues sólo de esta forma se ha podido hacer frente a la competencia de los productos de importación. Con este marco de referencia general podemos ubicar algunas líneas básicas que a nuestro juicio son necesarias para desarrollar una estrategia adecuada de conservación de la mariposa monarca.

Cómo protegerla

La monarca es el único insecto que hace un recorrido migratorio de más de 4,500 km. Uno de los grandes misterios de este fenómeno de migración es cómo las mariposas pueden recorrer una distancia que para su tamaño resulta astronómica. La forma en que estos pequeños insectos se orientan en su ruta, sorteando obstáculos naturales y peligros modernos, resulta igualmente asombrosa.

Sin embargo, la necesidad de nuevos conocimientos y comprensión de estos complejos procesos no corresponde sólo al campo de la biología de la mariposa; resulta urgente una mayor comprensión de las condiciones necesarias para la conservación del hábitat donde invierna la mariposa en México. A la fecha sigue habiendo controversia entre dos visiones de conservación diferentes: la de quienes buscan no tocar los recursos naturales para que se conserven y la de quienes consideran que es compatible utilizarlos y conservarlos.

Las experiencias en distintas áreas naturales protegidas del país y la de la propia región muestran que por las condiciones de las comunidades rurales los resultados de las estrategias conservacionistas ortodoxas son desastrosos.

En la región, el decreto para proteger la mariposa ha generado resultados contrarios a los que buscaba. La responsabilidad de los impactos destructivos del decreto en la zona no recae solamente en el gobierno que lo emitió, sino también en quienes lo promovieron, incluidos por supuesto aquellos que aprovechando la desinformación de la opinión pública en materia forestal han generado una y otra vez noticias amarillistas, buscando reacciones de alarma en torno al fenómeno. Esta confusión ha resultado provechosa para algunos que de este modo han obtenido notoriedad internacional, y los perdedores son los dos protagonistas centrales: los indígenas y campesinos propietarios de los bosques que cada vez están más pobres y la mariposa que ve cada vez más amenazado su lugar de refugio invernal.

El decreto ha devenido en instrumento de una política de conservación equivocada; sus resultados son negativos y de las acciones que contempla sólo se han cumplido las restricciones a las actividades productivas que ordena el artículo 8.

Once años después de su publicación, el programa integral de desarrollo contemplado en el artículo 2o. no se ha puesto en marcha. Sin embargo, el principal problema de este ordenamiento es el hecho de que fue elaborado y desarrollado de manera vertical y unilateral, pasando por alto la situación social de la región. Las tierras adonde llega la mariposa son de propiedad social en su mayoría, esto es, terrenos ejidales y comunales. A esta característica fundamental hay que añadir que se trata de una región densamente poblada, lo que, sin ser la única explicación del deterioro, hace más vulnerable la zona y genera mayor presión sobre los recursos naturales.

El diseño de la reserva no fue fruto de un estudio completo ni de la consulta a los actores sociales; fue un acto más político que planeado; los ejidos, las comunidades indígenas y los pequeños propieterios no fueron consultados, lo cual les generó confusión, enojo y rechazo. Las respuestas de las distintas comunidades fueron diversas, desde la aceptación aparente de algunas que han recibido ciertos beneficios, hasta las que han desmontado por no poder aprovechar su recurso forestal y por miedo a perder su tierra.

Las acciones institucionales desarrolladas hasta ahora, muy limitadas, han generado en muchos casos más desigualdad que beneficios. Con base en discusiones con las comunidades se presenta aquí un conjunto de propuestas que buscan ofrecer elementos para abordar el problema del deterioro de los recursos en la reserva.

No existe la menor duda de que el conocimiento biológico y de las necesidades de alimentación y hábitos del insecto es necesario para el tratamiento del fenómeno, pero más importante es conocer qué quiere o qué necesita la población local, cuáles son sus demandas más sentidas, cuáles sus intereses y prioridades, cuáles sus motivos más importantes en los procesos de toma de decisiones. Si las políticas y estrategias de conservación de la mariposa no se construyen con ese enfoque, se corre el riesgo de que continúen su carrera de fracasos. La situación demanda incorporar a la población en un proceso de desarrollo que permita mejorar sus condiciones de vida mejorando sus prácticas de uso de los recursos, pues sólo así puede asumir compromisos con la conservación de la mariposa.

Este proceso de desarrollo regional obliga a superar las visiones limitadas, las posiciones intransigentes de los actores; exige en cambio la voluntad política y la claridad de las autoridades de los diferentes niveles para una coordinación efectiva en el diseño y aplicación de las acciones. Ante todo es indispensable fomentar y fortalecer la organización de las comunidades más allá de las coyunturas electorales, de modo que se vuelvan interlocutores reales que no dependan del tutelaje ni mucho menos de la manipulación de las autoridades.

En el ámbito de los tres países que comparten el fenómeno es necesario definir claramente las responsabilidades y compromisos que a cada uno le toca cumplir. En este sentido cabe recordar que no es México el único país donde la mariposa está expuesta a riesgos y amenazas. No se cuenta con esquemas de evaluación, ni con cifras oficiales sobre las mariposas que mueren por exposición a insecticidas y plaguicidas en los campos de Estados Unidos, donde tampoco existen programas dedicados a modificar esquemas productivos para eliminar los riesgos que enfrenta la monarca.

La Reunión Trinacional sobre la Mariposa Monarca representa una buena oportunidad para discutir las responsabilidades y los compromisos concretos. Es urgente que los tres países elaboren un programa de apoyo común que disponga de recursos económicos suficientes y los aplique en aquellos lugares de mayor riesgo para la mariposa, como es el caso de los santuarios en nuestro país.

En México es importante reconocer los esfuerzos y el avance en la formulación de instrumentos de gestión ambiental, principalmente en los últimos tres años, pero aún tiene limitaciones debido principalmente a los escasos recursos destinados y las resistencias a generar una participación más amplia de las comunidades en la toma de decisiones.

Se requiere un esquema de cooperación internacional que sin vulnerar soberanías pueda definir los criterios generales de las acciones a seguir y la aplicación de los recursos económicos suficientes para el diseño de una estrategia de largo plazo. Un primer gran requisito de esta estrategia es la inversión productiva en la región, para poder favorecer patrones sustentables de uso de los recursos que sean compatibles con la conservación.

A comunidades, ejidos, propietarios privados y a la población en general no se les puede comprometer con la conservación si no cuentan con alternativas viables que les permitan vivir. Para nosotros está claro que son dos los grandes retos:

a. Mejorar las condiciones de vida de los habitantes del bosque.
b. Lograr la conservación de la mariposa monarca.

Qué necesitamos hacer en México

No tenemos mucho tiempo para actuar si queremos conservar el fenómeno migratorio de la mariposa monarca. Los campesinos propietarios de estos recursos son cada día más conscientes de que la solución está en sus manos, pues hay una rica experiencia en muchas comunidades del país que han logrado aprovechar sus recursos forestales. Sobre la base de este tipo de experiencias y con los objetivos mencionados, se conformó la Alianza de Ejidos y Comunidades de la Reserva de la Monarca, asociación civil que agrupa alrededor de 30 comunidades, integrada a la Red Mexicana de Organizaciones Campesinas Forestales, AC. La demanda central de la Alianza es la revisión del decreto, así como la lucha por mejorar las condiciones de vida de los campesinos mediante el aprovechamiento sustentable de los bosques y la conservación del fenómeno de migración de la mariposa.

La Alianza ha asumido el compromiso de la conservación de este fenómeno y del hábitat de invierno de esa especie, pero no puede hacerlo sola: es necesario que la sociedad civil sepa lo que esto significa y asuma en consecuencia los compromisos que le corresponden. Debemos también involucrar a los gobiernos federal, estatal y municipal para poder vencer las resistencias que hasta ahora han limitado el éxito de las acciones oficiales.

Esta organización campesina tiene la esperanza de echar a andar acciones que en el corto plazo permitan detener la destrucción de los recursos y aun hagan posible la restauración, lo que indudablemente repercutirá en el mejoramiento de las condiciones de vida de las comunidades indígenas, ejidos, pequeños propietarios y demás habitantes de la región.

En la región se cuenta ya con la cooperación del gobierno de Canadá, que ha facilitado recursos para trabajos de capacitación y para el desarrollo del programa Bosque Modelo.

En el cuadro que sigue se estiman los ingresos que han dejado de recibir los campesinos forestales de la reserva. Estimado a partir del valor potencial de los aprovechamientos forestales actualmente vedados, representa la deuda que la sociedad tiene con los poseedores de la zona, deuda que debe retribuirse con los mecanismos que resulten adecuados, excepto el de la venta de las tierras.

Cuadro 1	Ingresos que dejaron de percibir los campesinos relacionados con la Reserva de la Mariposa Monarca	
	Ingreso anual (miles de pesos)*	**Ingreso en 10 años (millones de pesos)***
Zona núcleo		
Sierra Chincua	37,930	418
Cerro Pelón	4,602	50
Sierra el Campanario	23,500	258
Cerro Chivatí-Huacal	13,400	143
Cerro Alamparon	2,400	22
Subtotal 1	*81,832*	*891*
Zona de amortiguamiento		
Sierra Chincua	2,700	30
Cerro Pelón	10,000	109
Sierra el Campanario	1,500	15
Cerro Chivatí-Huacal	12 440	130
Cerro Alamparon	681	8
Subtotal 2	*27,321*	*292*
Total	**109,153**	**1,183**

* 1997: 8 pesos = 1 dólar.

Propuestas de acción para una estrategia de conservación

- Revisar y corregir los errores cometidos en la emisión y aplicación del decreto.
- Reorientar las estrategias y hacer de la gente el actor central de las soluciones al problema.
- Instrumentar un programa de inversión para desarrollar alternativas para la población. Entre éstas, un proyecto amplio de ecoturismo y un programa de reconversión de las prácticas de aprovechamiento de los recursos.
- Construir mecanismos de cooperación entre los tres países, principalmente en materia económica.
- Definir claramente la responsabilidad de cada país en la conservación de la migración de la monarca.
- Incorporar de manera efectiva la participación de las comunidades en la toma de decisiones a través del fortalecimiento organizativo, sin tutelajes ni manipulación.
- Trascender la temporalidad sexenal de los programas en México. La planeación a largo plazo tiene que incluir la organización campesina, ya que son las comunidades las que permanecen y las que pueden efectivamente comprometerse a cuidar sus recursos a lo largo del tiempo.

- Retribuir de manera urgente a las comunidades por los ingresos que han dejado de percibir a consecuencia del decreto. Esta retribución debe hacerse a través del pago por conservación considerando los servicios ambientales.
- Poner en marcha un programa masivo de recuperación de áreas boscosas y detener el avance de la frontera agrícola. El programa debe cumplir tres objetivos básicos: ampliar las zonas de bosque, generar ingresos para la población y dar elementos para cambiar estrategias productivas.
- Concientizar a todos los actores que intervienen en el proceso de conservación, restauración y aprovechamiento sustentable de la región de la reserva. Éste es un requisito indispensable que permitirá priorizar acciones y canalizar los montos económicos necesarios para tener resultados en el corto plazo.
- Propiciar que la sociedad civil desarrolle una activa participación en el conocimiento de esta riqueza trinacional y sea una fuente de recursos económicos para su recuperación
- Canalizar los recursos necesarios para elaborar un efectivo programa de conservación de la zona, con la activa participación de las comunidades, que considere el replanteamiento del decreto de creación de la reserva y un programa masivo de reforestación a corto plazo.
- Cambiar de modo significativo el papel de los tres niveles de gobierno (federal, estatal y municipal) para convertirlos en conciliadores de los intereses legítimos de los diferentes actores sociales de la región.
- Realizar un programa de investigación que permita definir el tratamiento que requiere la masa forestal para que cumpla efectivamente la función de cobijo y alimento de la mariposa, esto como parte de un programa de uso múltiple de los recursos naturales de la región que eleve el nivel de vida de sus habitantes.

El desarrollo regional en la Reserva Especial de la Biosfera Mariposa Monarca

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Introducción

El conocimiento del fenómeno migratorio de la mariposa monarca y de su área de invernación en México generó una corriente de opinión en favor de la conservación de los recursos naturales, fundamentalmente los forestales, como la principal estrategia para garantizar la permanencia de esta maravilla natural. La expresión formal y legal de esta estrategia fue la publicación del Decreto de Creación de la Reserva Especial de la Biosfera Mariposa Monarca en 1986.

Independientemente de los criterios técnicos que sirvieron de fundamento para definir el número de "santuarios", los límites de cada uno y su diferenciación en zonas núcleo y de amortiguamiento, así como para establecer las restricciones al uso de los recursos naturales de esos territorios (criterios que han propiciado polémicas entre los especialistas y estudiosos del tema), es innegable que en la definición de dichas áreas no participaron los dueños de los terrenos ni se les consultó para informarles de las características, intenciones y consecuencias de esta decisión.

En este contexto, considerando que el uso productivo de los recursos naturales ha representado durante décadas una de las fuentes de ingreso más importante para los pobladores de esta región, el establecimiento de la Reserva Especial de la Biosfera Mariposa Monarca ha modificado radicalmente la forma de manejo de los recursos forestales en todos los predios cuya extensión forma parte, en menor o mayor proporción, de esta área natural protegida. A la modificación de la forma de manejo, los dueños de los terrenos respondieron de manera diferenciada: desde el fortalecimiento de estrategias de aprovechamiento ordenado ya existentes en algunos ejidos (la minoría) hasta el incremento de la tala ilegal en otros predios (por comunidades indígenas, principalmente).

La discusión actual se expresa básicamente en los siguientes aspectos:

1. ¿Deben mantenerse las actuales restricciones al aprovechamiento de los recursos forestales?
2. ¿Debe compensarse a los dueños de los predios ubicados en las zonas núcleo y de amortiguamiento?; de ser así, ¿de qué manera y en qué monto sería la compensación?
3. De no continuar las actuales restricciones al uso de los recursos naturales en los santuarios, ¿cuáles deben ser las medidas de protección en estas áreas?, ¿qué participación deben tener los dueños de los predios en su definición y aplicación?
4. En las presentes condiciones, ¿es compatible la conservación de las áreas de invernación de la mariposa monarca con el desarrollo social y económico de las comunidades locales?

De la naturaleza y alcance de las respuestas dependerá en gran medida el futuro de los recursos naturales de la reserva, de los habitantes de esa región y de la propia mariposa monarca. Este trabajo no pretende responder estas interrogantes, pero sí aportar algunos elementos de reflexión que contribuyan a la toma de decisiones sobre el particular.

Los recursos forestales, su aprovechamiento y problemática

A pesar de que el de México es un territorio de vocación forestal en su mayor parte, el aprovechamiento de esta riqueza apenas contribuye al producto interno bruto (menos del 1%). A nuestro país se le ubica como el cuarto lugar mundial en biodiversidad, misma que se localiza fundamentalmente en los ecosistemas forestales, sean de clima templado, tropical o de zonas áridas. Asimismo, los terrenos en los que se encuentran estos recursos son propiedad, en su mayor proporción, de comunidades indígenas y ejidos (más del 75% de la superficie forestal del país); si se expresa este dato de otra forma, tenemos que más del 90% de los grupos étnicos de México habitan en zonas forestales. De igual manera, son estas regiones donde se presentan las expresiones más lacerantes de la miseria y de injusticia social y económica que, en muchas ocasiones, son condicionantes para la aparición de conflictos sociales de trascendencia nacional.

La historia del aprovechamiento de la riqueza forestal de las comunidades indígenas, y recientemente de los ejidos, se ha caracterizado por el despojo y el engaño causados por agentes ajenos a las comunidades rurales, muchas veces al amparo del poder político. Sólo hasta hace poco tiempo (20-30 años), como resultado de luchas de grupos campesinos e indígenas, se han venido generando condiciones para que sean las organizaciones sociales propietarias de los terrenos forestales las beneficiarias del uso productivo de la riqueza forestal. El desarrollo de estas experiencias ha sido muy difícil, pues se han tenido que superar limitantes de diversa naturaleza: políticas, legales, financieras, organizativas, de capacitación, etcétera, pero finalmente estas experiencias demuestran que la mejor manera de conservar los recursos forestales es mediante el aprovechamiento ordenado y apropiado por parte de sus dueños, las comunidades locales.

A pesar de lo anterior, los productores forestales organizados enfrentan problemas que dificultan su desarrollo:

1. Los propietarios de los bosques han estado siempre marginados de apoyos oficiales para el desarrollo de sus actividades productivas. Mientras que los sectores agrícola y ganadero han sido favorecidos con políticas gubernamentales de estímulos, incentivos y subsidios, los productores forestales siempre han asumido los costos que representa el aprovechamiento ordenado de sus bosques (infraestructura de caminos, maquinaria y equipo de extracción e industrialización, asesoría y asistencia técnica, etcétera). Este año, por primera vez en la historia de este país, el gobierno federal y algunos gobiernos estatales están ejecutando el Programa de Desarrollo Forestal (Prodefor), con fondos acumulados de 46 millones de pesos (equivalentes a cinco millones de dólares estadounidenses) que serán destinados a atender necesidades técnicas y de capacitación de más de doce millones de mexicanos que viven en regiones forestales. Si se compara esta cantidad con los apoyos que reciben los productores agrícolas y ganaderos por medio de los programas oficiales Procampo y Alianza para el Campo, que en total suman más de 20,000 millones (equivalentes a casi 2.5 mil millones de dólares estadounidenses), se puede concluir que, efectivamente, los productores forestales se encuentran en total desventaja.
2. Los productores forestales del país enfrentan dos competencias de mercado: una interna, representada por los aprovechamientos forestales ilegales, realizados sin ningún control técnico, sin pago de impuestos, sin inversión en la protección al bosque (prevención y combate de incendios y plagas) y sin costos de fomento (reforestación). En algunas regiones del país, específicamente en Michoacán, los aprovechamientos no autorizados representan, en volumen producido, más del doble de la producción forestal autorizada. Obviamente, los precios de mercado de los productos forestales obtenidos al margen de la ley son más bajos y desplazan con facilidad a los productos resultantes de programas de manejo autorizados. La otra competencia, la externa, producto de la apertura comercial y de los bajos costos de la producción forestal de países como Estados Unidos y Canadá, prácticamente deja sin oportunidad a los productores mexicanos.
3. El valor de mercado de los bosques se ha restringido al cálculo monetario del precio de la cosecha de los productos maderables. Esto significa que un bosque tiene mayor valor mercantil si la cantidad de madera que se extrae es mayor. No se han generado y/o aplicado mecanismos que permitan incluir en este valor la importancia económica de los beneficios ambientales que proporcionan los recursos forestales (producción de agua limpia, retención del suelo, aportación de nutrientes a los suelos de las partes bajas de las cuencas, captura de carbono atmosférico, hábitat de fauna silvestre, etcétera).
4. Aunque ésta no es una situación exclusiva de nuestro país, la participación cada vez más activa de grupos ambientalistas que en ocasiones actúan con más buena fe que con conocimiento se vuelve un factor limitante para el desarrollo de proyectos productivos forestales de las comunidades locales. Si bien es cierto que el deterioro de los recursos naturales es el resultado de su mal manejo, causado principalmente por el interés en las ganancias rápidas, también es innegable que en la restauración se

requiere la participación activa y organizada de los propietarios de los terrenos. Esta participación es aún más importante en el manejo adecuado y sostenido de los recursos forestales que aún es posible aprovechar sin poner en riesgo su permanencia.

5. El mercado de las materias primas forestales es el conjunto de industrias de aserrío, de celulosa y papel, de aglomerados, entre otros. Para hacer posible un correcto manejo de los bosques y selvas, la industria forestal debe adecuarse, en tamaño y oferta específica de materias primas, al tamaño, calidad y posibilidades de manejo de los recursos forestales. En nuestro país, como en otras partes del mundo, esta situación ha sido exactamente la contraria: la demanda industrial de materias primas forestales ha definido cuánto, dónde, cómo, cuándo y qué cosechar de los bosques. Esta situación se agrava por el hecho de que la inmensa mayoría de los establecimientos industriales no son propiedad de los dueños de los terrenos forestales, lo que ha generado un conflicto de intereses muy difícil de superar. Para muchos expertos en este tema, una de las causas que explican el aprovechamiento inadecuado de los bosques y selvas es precisamente el crecimiento de la demanda industrial más allá de las posibilidades del recurso forestal para satisfacerla de forma sostenida.

Los recursos forestales en la Reserva de la Mariposa Monarca

La reserva tiene una extensión de 16,110 ha, de las cuales el 54% se ubica en el estado de Michoacán y el 46% restante en el estado de México. La mayor parte de esta extensión (72%) corresponde al área de amortiguamiento, en la que se permiten, con ciertas restricciones, algunas actividades productivas. En las zonas núcleo, que cubren la extensión restante, fueron prohibidas las actividades productivas de todo tipo y solamente se permite desarrollar tareas de investigación.

La reserva está conformada por cinco polígonos en los que se ubican los santuarios Cerro Altamirano, Sierra Chincua, Sierra del Campanario, Cerro Chivatí-Huacal y Cerro Pelón. Este último abarca el 50% del conjunto de la superficie de la reserva; el resto de la superficie corresponde a los demás santuarios en forma más o menos equitativa.

La mayor parte de la superficie de los santuarios (95.8%) está cubierta con algún tipo de vegetación forestal. Si de esta superficie se tiene en cuenta solamente la cubierta arbórea (9,834 ha), entonces su clasificación es como sigue: el 55.3% es bosque denso (con más del 75% de cobertura), el 28.1 es bosque cerrado (entre 40 y 74% de cobertura) y el 14.8 es bosque abierto (con menos del 40% de cobertura). Estas diferencias en la densidad del bosque son producto de las cortas ilegales que en pequeña y gran escala se llevan a cabo en la región.

El santuario con mayor superficie forestal perturbada es el de Cerro Pelón, con 1,847 ha de bosque deteriorado, esto es, 45.5% de la superficie del santuario y 18.8% del área forestal total de la reserva. Por otro lado, este santuario tiene 2,165 ha de bosque denso, extensión que constituye el 54.6% de su superficie forestal y el 22% del área forestal de la reserva.

Los bosques de los santuarios Sierra del Campanario y Chivatí-Huacal están considerablemente deteriorados en su mayor parte: 55.5% de la superficie forestal el primero y 68.9% el segundo.

Al santuario Cerro Altamirano le corresponde la menor superficie perturbada de toda la reserva: un 90% de bosque denso. El santuario Sierra Chincua también posee una alta proporción de bosques densos, 76% de su área forestal.

La reserva se compone de 57 predios (36 en Michoacán y 21 en el estado de México), ejidales y comunales en su gran mayoría. La superficie total de los predios afectados es de 65,163 ha, con una superficie forestal de 27,673 ha (42%). Si la población de los predios es de 99,390 habitantes, entonces la disponibilidad de superficie forestal es de 0.28 ha/hab, ello sin considerar las restricciones inherentes a las zonas núcleo y de amortiguamiento.

Si hacemos este ejercicio por entidad, tenemos que en el estado de México la superficie total de los predios afectados es de 13,617 ha, con una superficie forestal de 8,837 ha (65%); para una población de 21,033 habitantes, la disponibilidad de superficie forestal es de 0.42 ha/hab. En Michoacán, la superficie total de los predios afectados es de 51,546 ha, con una superficie forestal de 18,836 ha (37%), y la disponibilidad de superficie forestal de 0.24 ha por habitante.

Como podrá observarse, sin tener en cuenta las restricciones actuales a los aprovechamientos forestales maderables, la disponibilidad de superficie forestal para uso productivo es muy baja. Si se hace referencia a la disponibilidad de volúmenes de madera posibles de cosecha en función de los incrementos del arbolado, los resultados son como sigue: para la superficie total de los predios afectados con sistemas intensivos de manejo forestal, sin considerar las restricciones actuales, la cosecha posible sería de 117,295 m^3 v.t.a. de pino y 100,692 m^3 v.t.a. de oyamel, en total 217,987 m^3 v.t.a. de cosecha anual. La relación sería entonces de 2.19 m^3 v.t.a./hab, volumen que sigue siendo muy bajo para la satisfacción de las necesidades económicas familiares de los pobladores del área. Sin embargo, a este volumen habría que restarle la cantidad de madera que se deja de cosechar por las restricciones a los aprovechamientos maderables, lo cual representa aproximadamente un 40%, lo que significa una disponibilidad de 1.32 m^3 v.t.a. por habitante.

A partir de los datos anteriores sería erróneo concluir que siendo tan bajo el volumen por habitante, los aprovechamientos forestales maderables no son importantes para la economía regional, pero también sería equivocado afirmar que la actividad forestal maderable en sus condiciones actuales puede ser el eje conductor del desarrollo económico regional. No obstante, consideramos que si se introducen cambios tecnológicos, si se impulsan nuevas formas de organización para la producción y si se integran procesos de mayor generación de valor a partir de la actividad de extracción de la cosecha maderable, esta actividad sí se puede convertir en el motor del desarrollo económico regional.

Para que esto pueda ser realidad, se deben tener en cuenta los problemas mencionados a continuación y trabajar en su solución.

Problemática de la actividad forestal en la región de la Reserva de la Mariposa Monarca

Los aprovechamientos maderables autorizados para las zonas de amortiguamiento presentan importantes limitaciones.

Normativas

Las restricciones al uso productivo forestal en las zonas de amortiguamiento establecidas en el Decreto y otras disposiciones adicionales emanadas de las autoridades correspondientes se refieren básicamente a que:

- Los volúmenes de corta son menores, entre 20 y 25%, a los establecidos en los programas de manejo respectivos.
- Los aprovechamientos maderables deben realizarse fuera de la época de estancia de la mariposa monarca. De este modo las actividades de extracción de la madera deben realizarse durante los meses de abril a junio, por lo cual es frecuente que la extracción se concluya al inicio de la temporada de lluvias, y los costos de producción aumentan considerablemente, debido a que las vías de saca se vuelven intransitables.
- El tránsito de vehículos que transportan madera proveniente de aprovechamientos autorizados dentro del área de la reserva en las zonas de amortiguamiento, está restringido a caminos interiores y adyacentes a estas zonas, lo que encarece los costos de transporte.
- En los aprovechamientos maderables autorizados en las zonas de amortiguamiento deben establecerse franjas de “protección” adicionales de 30 metros alrededor de las zonas núcleo; en estas franjas no se puede derribar arbolado, lo que se traduce en disminución del volumen maderable por aprovechar, con el consecuente aumento en los costos de producción por unidad de volumen de madera.

Estas restricciones, en su conjunto, se traducen en mayores costos de producción y propician además pérdidas económicas a los productores, pues la calidad de la madera cortada se deteriora por exposición prolongada a la lluvia.

Limitaciones sociales

Son dos los aspectos especialmente problemáticos para el mejoramiento del manejo forestal:

- En la mayoría de los predios ejidales y comunales el bosque está parcelado y el manejo de estos parajes se realiza como si fueran propiedades particulares, lo que dificulta el ordenamiento territorial del manejo del bosque, además de hacer más compleja y costosa la asistencia técnica. Estas condiciones dificultan la transacción de la madera en rollo, pues cada parcelero vende en forma individual y con ello el que gana es el comprador; así, la capacidad de negociación de los ejidos y de las comunidades indígenas para comercializar los productos maderables disminuye significativamente, con el consecuente deterioro de la institución comunitaria.
- La apropiación del proceso productivo es aún incipiente. En la gran mayoría de los predios bajo aprovechamiento forestal autorizado (y clandestino) la industrialización de la madera la realizan agentes ajenos a las comunidades locales, por lo que el valor agregado y los empleos generados en el proceso no benefician a los campesinos dueños de los bosques.
- Las cortas de arbolado ilegales (“clandestinaje”) constituyen un problema complejo y de arraigada tradición en esta zona. Este problema se agravó durante los periodos de veda forestal que se dieron en los estados de México y Michoacán en distintas etapas del pasado reciente. Las cortas ilegales son resultado de un conjunto de factores que pueden manifestarse de manera aislada o integrada. Entre estos factores destacan la falta de opciones de empleo y acceso a tierras de cultivo, la creciente demanda de materias primas forestales de las industrias regionales, los requisitos y restricciones adicionales que impone la autoridad para la expedición de los permisos de aprovechamiento maderable persistente en la reserva, la falta de control organizado de los ejidos y comunidades sobre sus propios recursos naturales y la insuficiencia de fondos económicos para cubrir los costos de la asistencia técnica necesaria para obtener y conducir los aprovechamientos forestales autorizados (programas de manejo, trámites, servicios técnicos, reforestación, etcétera).
- Las cortas “clandestinas” afectan negativamente a los ejidos y comunidades de distintas formas, por una parte mantienen deprimidos los precios de la madera en la región y, en consecuencia, disminuyen las utilidades de los productores que trabajan con apego a la normatividad vigente. Afectan también fuertemente los recursos forestales, al ser realizadas las extracciones de madera sin ningún cuidado por el manejo y la regeneración del bosque. Los residuos resultantes de las cortas realizadas sin ningún control técnico se constituyen también en un peligro real ante la posibilidad de incendios forestales, pues el uso del fuego para “borrar” evidencias físicas de estos hechos se ha convertido en una práctica común entre los pobladores de la región.

Limitaciones económicas

El problema central se refiere a la escasa apropiación de los procesos de producción y a la limitada generación de valor agregado por parte de los dueños de los bosques. Los niveles de apropiación son:

- Para la mayoría de los predios se refiere a la carencia de autorizaciones para el aprovechamiento persistente, por lo que sus bosques no tienen manejo técnico, lo que impide obtener precios para la madera que cubran los costos de producción, incluido el impacto sobre los recursos; aunque en la mayoría de los casos, en los aprovechamientos persistentes existen costos que los precios de venta de la madera en rollo no alcanzan a cubrir, como el trabajo invertido en las reforestaciones, prevención y combate de incendios, vigilancia, etcétera.
- Los ejidos rentistas obtienen también beneficios menores a los que tendrían si controlaran y ejecutaran las distintas actividades del proceso productivo forestal.
- Los únicos cinco ejidos que controlan el proceso de extracción y la primera fase de industrialización (empresas de aserrío), representan los casos de mayor apropiación del proceso productivo forestal en la región, aunque llegan solamente a la producción de madera aserrada áspera y sin clasificación por calidades (sistema conocido como “mil-rum”).

Los ingresos económicos que obtienen los predios rentistas (por metro cúbico de madera en rollo) son apenas el 36% de los ingresos que reciben los productores de madera aserrada, y solamente el 8% de los ingresos que tendrían si la integración de la producción llegara a niveles de generación de bienes terminales tales como muebles, molduras, etcétera.

Otro problema importante es la falta de financiamiento para la producción en las empresas forestales campesinas. Estas empresas sociales enfrentan un problema de descapitalización crónico causado, entre otros factores, por los limitados índices de ganancia con que operan. A ello se añade el hecho de que esa ganancia debe ser repartida entre los ejidatarios socios, cuya economía individual les impide invertir en el crecimiento de la empresa forestal, hasta llegar a dificultar incluso su reproducción simple. La falta de reinversión y el reparto de las ganancias afectan en ocasiones el capital de producción, es decir, el financiamiento de las operaciones anuales. Las posibilidades de nuevas inversiones destinadas al mejoramiento y desarrollo industrial, a partir exclusivamente de los recursos y esfuerzos de los ejidos, son lamentablemente muy precarias.

En este contexto, cabe reflexionar sobre los siguientes aspectos:

- ¿Es justo cargar sobre los hombros de la economía campesina los costos del manejo forestal?
- ¿Es justo sumar a esos costos el costo que representa la protección del hábitat de la mariposa monarca?
- ¿Es conveniente que se siga valorando al bosque por el volumen de madera que se pueda cosechar?
- ¿Es iluso pensar que debe valorarse el bosque por el simple hecho de existir y por los beneficios ambientales que a toda la sociedad nos proporciona su existencia?

Conclusiones y recomendaciones

- Con o sin la veda inherente a la existencia de la reserva, el clandestinaje forestal tuvo y tiene una fuerte presencia en la región. La única opción viable para frenarlo es hacer partícipes al mayor número posible de ejidos y comunidades indígenas con potencial forestal en el manejo ordenado y persistente de sus bosques.
- La incorporación de un mayor número de predios al manejo forestal permanente es no sólo una condición necesaria para frenar el clandestinaje, sino también una medida sin la cual el enriquecimiento de las masas forestales y la restauración de las áreas forestales degradadas no son posibles. Asimismo, es condición indispensable para convertir, en el mediano plazo, la actividad forestal en uno de los ejes fundamentales del desarrollo regional.
- Es inaplazable el control de las fuentes de abastecimiento de materias primas forestales para asegurar que el funcionamiento de la industria regional corresponda a las posibilidades reales de crecimiento del bosque. En consecuencia, este control contribuiría significativamente a la disminución de las cortas ilícitas de arbolado en esta región.
- La participación campesina en los aprovechamientos forestales deberá basarse en la apropiación gradual de los procesos de producción forestal, lo que incluye la transferencia tecnológica y la capacitación técnica en las actividades de manejo forestal, fomento, protección, administración, comercialización e industrialización.
- Debe encontrarse la forma de simplificar y agilizar los trámites institucionales que los productores realizan para obtener las autorizaciones de aprovechamiento de sus bosques; de modo que el manejo forestal ordenado sea una opción que compita ventajosamente con los aprovechamientos ilícitos y de esta manera hacerla atractiva ante los dueños del recurso.
- El incremento de la generación de productos con mayor valor agregado es una necesidad cuyo impulso es inaplazable por su capacidad para generar empleos (se generan entre seis y siete empleos en las fases de transformación de la madera por cada empleo que se genera en la obtención de materias primas forestales) y por otros beneficios como contribuir a la valoración social de los recursos forestales.

- Es necesario reorientar el gasto público para lograr el equilibrio de los apoyos, incentivos y subsidios que se destinan al sector rural. En la medida en que la actividad productiva forestal de los dueños de los bosques sea impulsada con estos mecanismos, se puede esperar un mejor manejo de estos ecosistemas, mayor contribución de este sector productivo a la economía regional y nacional y, sobre todo, un mejor nivel de vida de las comunidades indígenas y ejidos forestales. Si realmente se desea la conservación del hábitat de la mariposa monarca y de los bosques de la región, que son de los más productivos en su tipo en el mundo y que por este solo hecho vale la pena conservarlos mediante su manejo ordenado, no debemos perder de vista que para lograrlo se requiere el desarrollo social y económico de las comunidades locales.
- Finalmente, es necesario emprender una campaña de educación ambiental para toda la sociedad (incluidas algunas autoridades gubernamentales), de modo que se comprenda que el aprovechamiento ordenado de los bosques por parte de sus dueños no sólo no pone en riesgo la existencia del hábitat de la mariposa monarca, sino que es una de las condiciones necesarias para garantizar su permanencia en el tiempo, para beneficio de las generaciones actuales y futuras.

Propuesta metodológica de participación social para la Reserva Especial de la Biosfera Mariposa Monarca

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La invención de la RBMM o la falta de acuerdos para la creación de un área natural protegida

Negar que la creación de la reserva de la biosfera ocasionó conflictos en la región sería mentir, pues desde 1986, cuando se publicó el decreto de creación de los cinco santuarios para la protección de la mariposa monarca, se provocó paralelamente un problema social porque no fueron consultadas las personas que serían afectadas por el decreto, ni posteriormente se les ha explicado en qué consiste dicho documento. Esto provocó en ellos un fuerte resentimiento y desconfianza hacia el Instituto Nacional de Ecología (INE), pues de un día para otro, aunque siguieron siendo dueños de sus tierras y recursos, quedaron en situación de no poder realizar ninguna acción de aprovechamiento sin la autorización correspondiente del INE. Con lo anterior, se observa en la actualidad un campesinado que, inconforme, se niega a participar en cualquier acción de conservación si no se recibe a cambio algún tipo de pago, sin importarle que las acciones que se realizan sean en beneficio de ellos y de sus descendientes.

El trazo de los polígonos de protección para la mariposa monarca permite de manera fácil a cualquier observador darse cuenta de que no se consideraron las características geográficas de la zona; se puede observar que en la mayoría de los casos se tienen líneas trazadas en ángulos que no corresponden a las condiciones ecogeográficas de la región, ni mucho menos a los intereses de los habitantes de la zona.

De haber considerado a los habitantes de la región como los principales informantes para la definición de las extensiones y límites de las zonas de protección para el arribo e invernación de la mariposa, los resultados en el trazado de los polígonos se apegarían a la realidad sobre el fenómeno de invernación de la mariposa, lo que habría permitido una socialización de la información y concientización de la población sobre la necesidad e importancia de conservar sus recursos.

Un paso antes del decreto

Los problemas ambientales en la región no son recientes; el aprovechamiento indiscriminado de los recursos ha llevado a la región a sufrir una serie de crisis cuya expresión más visible es el cambio de actividades productivas para la subsistencia de la población.

Un ejemplo de esto fue la minería como actividad generadora de los ingresos económicos más importante para la región en la segunda mitad de este siglo, lo que propició el crecimiento de poblados y pequeñas ciudades a su alrededor. La extracción minera tenía en la explotación del recurso forestal una actividad complementaria para su funcionamiento. Con el transcurso del tiempo y el agotamiento de los recursos mineros se fue reduciendo la capacidad de contratación de mano de obra; tuvo la necesidad de nuevas fuentes de empleo hizo que la población recurriera a tierras no aptas para la producción agrícola y propiciara la disminución de la superficie boscosa. Otro segmento de la población se dedicó a la explotación incontrolada de los recursos forestales. Esta situación ha continuado durante muchos años provocando la marginación de la población de la región.

La entrada en vigor de los decretos de 1980 y 1986, en los que se estableció que la mariposa monarca y los lugares a los que llega quedaban protegidos, provocó un gran malestar entre la población impedida de seguir utilizando los bosques para su subsistencia.

Decreto y conservacionismo a ultranza

A partir de 1986, cuando ya se había establecido la reserva, se comenzó un trabajo enfocado a la conservación de la zona para el arribo de la mariposa, en el que la participación comunitaria ha sido simplemente comprendida como mano de obra barata que se emplea en acciones de conservación como la reforestación, brigadas contra incendios forestales o como ayudantes de campo para los responsables de realizar el monitoreo de especies. Sin embargo, su opinión sobre el manejo de los diversos recursos existentes en la zona, como son el bosque, el agua, la flora y la fauna, no es tomada en cuenta, y sí enfrentan a cambio una serie de restricciones para poder utilizarlos o para realizar cualquier otra actividad económica en el área protegida, pues toda iniciativa de uso de sus recursos tiene que ser antes que otra cosa evaluada por especialistas. Sin embargo, estas evaluaciones tardan mucho en realizarse, por lo cual la gente que pretendía ejecutar aprovechamientos forestales legalmente autorizados termina por hacer las cosas de manera más fácil talando clandestinamente y poniendo así en riesgo los sistemas de las Áreas Naturales Protegidas.

Por otra parte, los diversos intentos oficiales para el aprovechamiento campesino de la estancia de la mariposa monarca en la región, como el impulso de la actividad turística, han sido mal enfocados y faltos de planeación, por lo que sólo se han beneficiado los actores sociales que cuentan con recursos propios para disponer de una infraestructura mínima y brindar los servicios necesarios. Como ejemplo de lo anterior basta mencionar a los propietarios de los hoteles, transportistas y restauranteros, quienes acaparan la mayor parte de los ingresos económicos derramados por el turismo y no tienen ningún compromiso con los ejidos afectados por la reserva o con el Instituto Nacional de Ecología para conservar la zona de los santuarios. En cambio, los menos beneficiados son los ejidatarios afectados por el decreto; ejemplo de esto es el ejido El Rosario, donde la participación de la comunidad en la prestación del servicio turístico se restringe sólo a alquilarse como guías y vigilantes del santuario durante la temporada de estadía de la mariposa o como cuidadores de automóviles en el estacionamiento. La captación de los ingresos del turismo es mínima. Sin embargo, es a los campesinos a quienes se les obliga a acatar una serie de normas restrictivas para conservar el servicio de apertura al turismo.

Lo anterior demuestra que los habitantes de la zona son afectados de manera directa o indirecta por el decreto y que su participación en la toma de acuerdos y decisiones es mínima y generalmente está enfocada a que den su aprobación a las propuestas institucionales. Si queremos que la situación cambie, que la presión que ejercen las sociedades locales sobre sus recursos sea menor y que logren una participación activa en la conservación, restauración y cuidado de los recursos, debemos establecer formas de comunicación entre los afectados y el Instituto Nacional de Ecología. La reorientación del trabajo institucional debe ir enfocada a la búsqueda de acuerdos para el apoyo y la participación de los distintos sujetos sociales en el manejo y protección de todos los recursos del área protegida.

El arrepentimiento o la nueva relación: una propuesta metodológica

La búsqueda de modelos de desarrollo sustentable está orientada a definir alternativas de crecimiento sostenido de la sociedad, que no sólo abarquen el aspecto económico, sino que tenga un alcance más amplio que incluya satisfactores sociales y culturales y al mismo tiempo garantice la disponibilidad futura de los recursos naturales y su conservación. En la Reunión Cumbre de Naciones Unidas celebrada en 1992, en Río de Janeiro, Brasil, los países participantes, entre ellos México, acordaron promover el desarrollo sustentable, entendido como una posibilidad de desarrollo integral que busca resolver y satisfacer las necesidades de toda la sociedad, incorporando criterios que aseguren un adecuado uso de los recursos, naturales, sociales, económicos y culturales. El desarrollo sustentable es, en otras palabras, una posibilidad de equilibrio y articulación entre las necesidades de las población (empleo, producción, salud, educación, recreación, bienestar social, cultura, justicia, legalidad, comunicación e información) y la disponibilidad y calidad de los recursos, respetando y desarrollando las capacidades de las sociedades para decidir su futuro a través de sus formas propias de consulta, consenso y toma de decisiones.

Con una nueva administración en la Reserva Especial de la Biosfera Mariposa Monarca en 1996 se ha buscado un cambio en las relaciones entre la reserva y las sociedades locales que son afectadas. Como primer paso se quiere la participación de las comunidades en los procesos de planeación y toma de decisiones, lo que debe contribuir a impedir la concentración de autoridad y de recursos en grupos minoritarios con intereses contrarios a los de la mayoría. Para que la descentralización sea efectiva y promueva el bienestar de la población debe ir acompañada de la participación comunitaria. En otras palabras, se busca fortalecer y desarrollar organizaciones consolidadas y validadas por las sociedades locales preocupadas por el aprovechamiento, la conservación y la restauración de su ambiente.

Como parte del seminario interno de capacitación para el personal técnico de la Reserva Especial de la Biosfera Mariposa Monarca se realizaron varias reuniones de discusión para definir una serie de conceptos y metodologías que buscan orientar el trabajo que se ha propuesto desarrollar en las comunidades ubicadas dentro del área de influencia de la Reserva Mariposa Monarca.

La propuesta de la REBMM enfoca su trabajo a las organizaciones sociales con el objetivo de promover acciones de microdesarrollo sustentable, un quehacer social en el que las sociedades locales construyen su autonomía, entendida como la capacidad para decidir en favor del interés propio; significa un ejercicio de autogestión de recursos y sobre todo una oportunidad real para la definición de opciones de futuro. Avanzar en este sentido nos compromete a darle forma y contenido al desarrollo de las sociedades locales, al mismo tiempo que se amplían y consolidan los espacios para el pleno ejercicio de los derechos políticos, jurídicos, sociales, culturales y ambientales de las comunidades.

En este sentido, promover opciones de desarrollo significa la posibilidad real de participación de los sujetos sociales en el manejo y conservación de sus recursos con acuerdo a sus usos y costumbres. La propuesta de realizar talleres para el manejo sustentable de los recursos no es otra cosa que el acercamiento a las sociedades locales y la discusión para lograr satisfacer su sistema de necesidades de acuerdo con un empleo adecuado a sus usos y costumbres, que les permita desarrollar una estrategia de futuro viable y sostenida con los recursos de que disponen, sin menoscabo de su calidad o nivel de vida.

La reorientación del trabajo del equipo técnico de la REBMM corresponde a una nueva visión en la que parte de las acciones de conservación y desarrollo sustentable esté dirigida a las acciones de la cogestión con las sociedades locales y a la reflexión sobre el impacto de los Programas de Trabajo establecidos por los representantes comunitarios.

La propuesta de la Dirección de la REBMM se basa en la realización de talleres comunitarios para el microdesarrollo sustentable en comunidades indígenas y campesinas de la región de la reserva. Esta actividad deberá partir de los siguientes principios:

- La concientización colectiva de la problemática ambiental de su región.
- La construcción comunitaria de los planes de microdesarrollo sustentable.
- El reforzamiento de la capacidad interna comunitaria de participación y gestión.
- Las disposiciones necesarias para que las organizaciones tengan la capacidad de acceder a los espacios de gestión, participación y toma de decisiones en los distintos ámbitos institucionales.

La elaboración del documento metodológico para la realización de los talleres para el microdesarrollo sustentable tiene un carácter propositivo, puesto que la definición y adopción de la metodología se adecua a cada comunidad, pero la parte medular de esta propuesta se basa en la elaboración conjunta, entre los sujetos sociales y el personal técnico de la reserva, de un diagnóstico general y una planeación de las posibilidades de futuro. Para lograr esto debemos de dividir el taller en tres etapas:

- Historia de la comunidad.
- Situación actual de la comunidad.
- El futuro posible de la comunidad.

El resultado final del taller comprende la elaboración de un plan de manejo integral por cada comunidad participante.

Los objetivos que se persiguen son:

- Elaborar diagnósticos de la situación actual de la comunidad que propicien la ejecución de acciones tendientes a la conservación, restauración y aprovechamiento racional de los recursos de las sociedades locales.

- Establecer, junto con las sociedades locales, alternativas de solución a su sistema de necesidades a través de la elaboración de programas de trabajo comunitario que serán la base para la conformación de planes de microdesarrollo sustentable.

Las reflexiones finales

La propuesta no intenta descubrir nuevas formas de acercamiento y trabajo con las sociedades locales, pues ejercicios de este tipo se han desarrollado en nuestro país en los últimos diez años. Lo que buscamos es propiciar un cambio en la forma en que toma las decisiones la institución encargada de velar por las áreas naturales protegidas. Lograr que los habitantes de las zonas rurales e indígenas participen y asuman en realidad el manejo, protección y administración de sus recursos, de modo que puedan alcanzar una subsistencia digna sin atentar contra sus costumbres. El objetivo final es que en el proceso de conservación y restauración del ambiente se involucre a toda la sociedad.

La conservación de la monarca, reto para la organización campesina

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En octubre de 1986 se expidió un decreto para proteger las áreas naturales que sirven a la migración, invernación y reproducción de la mariposa monarca y la conservación de sus condiciones ambientales, en una superficie de 16,110 hectáreas ubicadas en los municipios de Ocampo, Angangueo, Zitácuaro y Contepec, en la región oriente del estado de Michoacán, y Donato Guerra, Villa de Allende y Temascalcingo, en el occidente del estado de México.

Esta medida se justificó como una estrategia en materia de ecología, ya que se consideraba prioritario establecer medidas preventivas para regular el aprovechamiento integral y racional de los recursos naturales renovables y realizar acciones orientadas a la conservación y enriquecimiento de los ecosistemas de interés especial “cuya fragilidad las hace susceptibles de alteración por las actividades humanas”, conservando así su belleza natural.

El decreto distingue dos tipos de territorios, los de amortiguamiento y los núcleos; estos últimos constituyen el hábitat indispensable para la permanencia del fenómeno migratorio de la mariposa monarca y el banco genético de las diversas especies que ahí habitan. En estas áreas las únicas actividades permitidas son las de investigación; se decretó en ellas una veda total e indefinida de la explotación forestal y en general el aprovechamiento de la flora y la fauna silvestre. En las zonas de amortiguamiento, aquellas que se destinan a proteger las zonas núcleo del impacto exterior, se pueden realizar actividades productivas, dentro del marco de normas ecológicas encaminadas a la protección del ambiente.

El descontento entre los habitantes de la región comenzó cuando ellos, los propietarios de las zonas, se enteraron de que ya no podrían explotar los recursos o lo tendrían que hacer de forma restringida. El rechazo al decreto responde a distintas razones. En primer lugar se le rechazó porque la creación de la Reserva nunca fue consultada con las comunidades afectadas, sino impuesta como un medida conservacionista, sin considerar los intereses de los campesinos. Otro punto de conflicto y confusión ha sido que el decreto no establece quiénes y cómo deben conservar los recursos, pero las autoridades de gobierno se adjudican el control de la reserva, mientras que la factura de los costos de la conservación recae en los campesinos. El decreto se promulgó sin que se contara con suficientes bases técnicas ni con información social para fundamentar su establecimiento; a lo largo de los años se ha hecho patente su falta de funcionalidad y eficiencia. Pero sin duda el problema principal de la creación de la reserva es que ha provocado una disminución drástica de las fuentes de ingreso para los habitantes.

Poco a poco campesinos de distintas comunidades, los líderes campesinos regionales e incluso comunidades agrarias completas, unidos por el rechazo al decreto, confluyeron en la formación de organizaciones campesinas regionales. En los últimos 30 años en la región han nacido y muerto diversas organizaciones sociales. Algunas surgieron con objetivos comerciales y productivos, otras para ejercer y establecer mecanismos de control político corporativo sobre las comunidades campesinas. En su mayoría desaparecieron por problemas de corrupción o por falta de participación. A pesar de esas experiencias desalentadoras, en distintos momentos la organización campesina ha sido un espacio de construcción de propuestas alternativas para la solución de la problemática regional. Fue así como 17 comunidades decidieron en 1995 integrar la Alianza de Ejidos y Comunidades de la Reserva de la Mariposa Monarca, AC (AECRMM). Actualmente la Alianza está integrada por 31 ejidos y comunidades indígenas ubicados en los estados de Michoacán y México. En estas comunidades viven cerca de 6,000 ejidatarios y comuneros y una población total de aproximadamente 40,000 personas.

La Alianza surgió como una respuesta campesina a la desatención de las instituciones de gobierno hacia las comunidades, buscando enfrentar los problemas que se han generado a partir de la aplicación del decreto de 1986. Esta organización es la primera agrupación campesina que en esta región ha propuesto opciones al desarrollo regional y comunitario, impulsando además acciones para conservar las áreas de invernación de la mariposa monarca. La Alianza ha demandado reiteradamente la revisión del decreto y ha exigido para las comunidades campesinas el acceso a la toma de decisiones referentes al mejoramiento de las condiciones de la reserva y de sus pobladores. Solicita también la activación de mecanismos compensatorios para cubrir los costos económicos y sociales de las restricciones a los aprovechamientos de los recursos en las zonas núcleo.

Entre algunos empleados y funcionarios de gobierno la presencia de una organización social en la reserva ha causado recelo y desconfianza que se han traducido en el bloqueo de las iniciativas y gestiones de la Alianza. Ésta sostiene una serie de reivindicaciones que responden a las dificultades y tensiones —cada vez mayores— de los campesinos forestales de la zona, que se volvieron más complejas a raíz de la emisión del decreto de 1986.

La acción de las instituciones oficiales se ha caracterizado por la falta capacidad de respuesta y la constante búsqueda de control de las comunidades; en este escenario es muy importante contar con una organización campesina regional, independiente, más aún si sostiene demandas claras y propuestas concretas. La AECRMM propone trabajar con las dependencias de gobierno y con todos los actores relacionados con los procesos económicos, sociales y ambientales de la población regional, enfrentando los distintos problemas en un marco de respeto y esfuerzo conjunto para encontrar soluciones e impulsar acciones que beneficien a los distintos actores. Sin embargo, pese a que hay mucho interés, las inercias institucionales y políticas frenan los procesos organizativos, obstaculizan la capacidad de generar nuevas formas comunitarias de aprovechamiento de los recursos naturales, tendientes a mejorar las condiciones de vida de la población de la reserva. A lo largo de la historia reciente de la región, de la REBMM y de la propia Alianza, los ejercicios de cooptación y el hostigamiento a los líderes campesinos han sido constantes. Al parecer, las dependencias de gobierno no consideran que las organizaciones campesinas puedan ser el mejor canal para llevar a cabo programas de desarrollo regionales o locales. No se contempla que las organizaciones campesinas surgen en respuesta a las problemáticas creadas por las condiciones de pobreza, sino que se les percibe como fuerzas destructivas, contrarias por definición a las políticas gubernamentales, de ahí que se busque precipitadamente obtener el control de los distintos espacios de participación social. En estas condiciones, la preservación de la organización campesina como un espacio autónomo de reivindicación representa un reto considerable.

La propuesta campesina

Desde su creación la AECRMM ha optado por la consulta directa a los habitantes de las comunidades afectadas por el decreto como estrategia de construcción de consensos. Mediante talleres de planeación participativa se busca que sean los actores directamente involucrados quienes definan el origen de los problemas y diseñen propuestas alternativas. A partir de estos espacios se ha definido que la mejora de las actividades productivas de la zona requiere trabajo, voluntad política y proyectos productivos alternativos. En estos espacios se ha definido también que un primer paso se debe dar en el ámbito de los ordenamientos legales, fundamentalmente con la revisión seria del decreto de creación de la reserva. Esto se debe a que las condiciones y los supuestos bajo los cuales se formuló han resultado inoperantes, y la experiencia de doce años demuestra que para la región la estrategia meramente conservacionista resulta inviable. Por otra parte, distintas experiencias de silvicultura campesina muestran que el éxito en la conservación de los recursos forestales se ha logrado mediante el aprovechamiento ordenado de los recursos.[1]

Además de los problemas de concepción, el decreto de creación de la REBMM contiene distintos problemas técnicos, entre los que destaca la falta de correspondencia (en muchos casos) de las colonias de invernación de las mariposas y las zonas de protección. Éste es el caso del santuario Cerro del Campanario, en una de cuyas dos zonas núcleo no se han establecido colonias de mariposas desde hace años, y del ejido El Rosario, donde las mariposas invernan fuera de la zona núcleo, ya que la colonia se ubica en los límites de la zona de amortiguamiento y el área libre. Los campesinos de este ejido han

[1] Klooster, Daniel, "Cómo no conservar el bosque: la marginación del campesino en la historia forestal mexicana", *Cuadernos Agrarios*, núm 14, julio-agosto de 1996, pp. 115-144.

dejado de realizar aprovechamientos forestales en el área de la colonia para ofrecer el espectáculo de las monarca a los turistas que visitan el santuario; sin embargo, no pueden aprovechar el bosque en la zona decretada como núcleo, a pesar de la ausencia de colonias.

En los distintos bancos de información consultados —incluido el del Instituto Nacional de Ecología— no aparece un expediente técnico que justifique el decreto y sólo se menciona el "descubrimiento" oficial de las colonias en 1975. Por otra parte, los testimonios de los habitantes apuntan a que no se desarrolló trabajo de campo para registrar las áreas de invernación, sino que la medida se tomó precipitadamente, como reacción a las presiones de grupos ecologistas urbanos.

La acostumbrada exclusión de las comunidades campesinas en las definiciones de las políticas gubernamentales ha sido extrema en la definición de los programas de manejo para la protección de ecosistemas críticos, aun cuando las comunidades sean dueñas de los territorios afectados. Con el transcurso del tiempo, la dificultad de mantener la reserva sin intervención es cada vez más patente, no sólo por razones de tipo social, sino aun debido a factores de orden natural. Es así como desde hace algunos años en los bosques de la reserva la necesidad de manejo forestal es cada vez mayor para controlar las plagas en las zonas núcleo —donde las intervenciones humanas están prohibidas. Estas condiciones, además de las consideraciones sociales, hacen que las estrategias de corte conservacionista ortodoxo resulten insostenibles en los casos de bosques fragmentados como los de la Reserva de la Mariposa Monarca. En este sentido resulta ilustrativo el ejemplo del bosque del Desierto de los Leones, cercano a la Ciudad de México. Este bosque, similar al de la reserva, no ha sido manejado, se encuentra plagado, carente de regeneración natural, y ha perdido importantes áreas de oyamel. Un proceso semejante ocurre en las zonas núcleo de la reserva, donde grandes superficies de los santuarios Sierra Chincua (en la propiedad federal y en el ejido de Cerro Prieto) y Cerro Pelón (en la comunidad indígena de Nicolás Romero) se encuentran seriamente deterioradas debido a la invasión de *Scolytus* y a los incendios. Las prescripciones del decreto han impedido retirar la madera muerta, a pesar de que representa un foco de infecciones e incrementa el riesgo de incendios.

Las modificaciones necesarias deben realizarse a partir de una intensa campaña de información y consulta a las comunidades indígenas y a los ejidos, incluidos los distintos sectores de la sociedad interesados en la preservación de la REBMM, de forma que se inicie una discusión amplia, de la que surjan nuevas propuestas sobre cómo se debe proteger a la mariposa monarca y los recursos naturales de la región.

Por otra parte, a más de una década de la expedición del decreto que creó la reserva, los propietarios de los terrenos afectados no han recibido una compensación por la imposibilidad de aprovechar los recursos existentes en los terrenos de su propiedad. Esta situación resulta contraria a la conservación de los recursos porque, ante la imposibilidad del uso regulado por la comunidad, se provoca la apropiación individual y no regulada de los recursos comunes, vulnerando de este modo el tejido de la organización interna de las comunidades. Aquellas que han mantenido su cohesión interior luchan por no desmantelarse frente a la necesidad de cada uno de los miembros de aprovechar los recursos, aunque ahora de manera clandestina.

Uno de los mayores retos para el manejo responsable de los recursos y del hábitat de la mariposa es corregir la normatividad para el aprovechamiento comunitario; al mismo tiempo las dependencias se tienen que replantear su acción a fin de hacer más ágiles los trámites necesarios para el aprovechamiento de los recursos. En este sentido, la tardanza y las dificultades para conseguir las autorizaciones de aprovechamiento forestal en forma legal, impiden el ejercicio de la autoridad y deterioran la relación entre las instituciones públicas y los liderazgos campesinos. Incluso en las zonas libres vecinas a la reserva, las comunidades sufren problemas de burocratismo similares, que dificultan sus esfuerzos por aprovechar sus recursos dentro de los marcos legales mientras enfrentan la competencia desleal de la abundante madera de origen clandestino en la región.

El costo de la gestión para el aprovechamiento forestal del área debería cubrirlo la sociedad que exige la protección de la mariposa monarca, de tal suerte que si por cuestión de orden público e interés social se ha decretado la protección de esta especie, ocasionando con ello un daño a los dueños de las áreas de invernación, sean las sociedades nacional e internacional las que financien su protección. El desarrollo de esta propuesta requiere una serie de políticas de desarrollo regional consensadas que considere a las comunidades, a las organizaciones locales y a los agentes externos interesados en la conservación.

Entre los proyectos que representan una alternativa económica se cuenta el ecoturismo. Hasta ahora, aun sin promoción, arriban anualmente más de 100,000 turistas a los santuarios durante la estancia de la monarca, y se considera que el potencial de la actividad es mayor en 200 por ciento. Una propuesta de las organizaciones debe considerar el apoyo a iniciativas ecoturísticas que conformen un plan integral de difusión, atención al visitante, mejoramiento de la infraestructura, capacitación a los dueños de los santuarios y al personal que atendería a los visitantes, un sistema de vigilancia y seguridad, así como el monitoreo del cumplimiento de las normas ecológicas respectivas.

La propuesta de la Alianza es que se abran al turismo todos los santuarios y que se constituya un corredor turístico que considere, además de la visita a los sitios de invernación de la monarca, los paisajes regionales, los balnearios, la arquitectura de algunas de las localidades y otros atractivos de la región.

El impulso a proyectos de desarrollo comunitario y regional debe ser una prioridad porque representa una medida imprescindible para reducir la presión social sobre los bosques de la reserva. Faltan lineamientos políticos claros para impulsar el trabajo, muchas veces frenado por una lógica de administración de los recursos decidida por funcionarios con poca visión y sensibilidad social.

La dirección de la reserva se ha caracterizado por inoperante: las iniciativas que ha promovido tienen más relación con la investigación que con el desarrollo de la zona. La AECRMM considera más adecuado que el trabajo que realiza esta dependencia lo retome un equipo de expertos universitarios quienes, junto con un patronato de asistencia, decidan las labores por realizar en la reserva. Asimismo consideramos que los recursos de que dispone esta dirección pueden destinarse a un programa de desarrollo comunitario.

En esencia, la participación de las poblaciones en la gestión de los recursos y la conveniencia de que se beneficien primero sus habitantes son elementos básicos para la sustentabilidad del hábitat de la monarca; por lo demás, en la actualidad estos elementos se consideran en los lineamientos de operación de fondos de organismos internacionales de financiamiento, como el Banco Mundial. En esta discusión es muy importante aclarar qué es lo que se pretende conservar, quién lo debe hacer, cuál es la dinámica de los fenómenos culturales y sociales que intervienen en los procesos de deterioro ambiental, a fin de llegar a una idea funcional de las políticas, instrumentos y medidas a aplicar.

En este sentido es urgente replantear la estrategia de “no tocar” aplicada a las zonas núcleo y sustituirla por una que apunte a mantener y mejorar el bosque mediante un programa de manejo integral de recursos.

Sólo en la medida en que existan apoyos, orientación, capacitación y lineamientos claros para el desarrollo de actividades productivas de las comunidades de la región de la monarca será posible que los dueños de los recursos se conviertan en los principales protectores de estas áreas y, consecuentemente, de la propia mariposa.

Reforestation as a strategy for restoring monarch ecosystems

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Abstract

Deforestation in the monarch overwintering area in central Mexico has caused a pattern of significant ecosystem changes. This pattern is characterized by a diminished natural resource base for the *ejido* communities in the area, as well as ecosystem degradation associated with the extensive changes in forest cover. The degradation includes direct habitat loss and changes in the microclimate affecting overwintering butterflies, soil erosion and reduced soil productivity, and damage to aquatic ecosystems caused by erosion and sedimentation of streams draining the area, as well as changes in hydrology. The objective of the La Cruz Habitat Protection Project and the Michoacán Reforestation Fund is to conserve the forest ecosystems upon which the monarchs and human inhabitants of the area depend. The primary strategy developed and used by the La Cruz Project is to encourage reforestation of lands comprising *ejidos* as an alternative to ongoing forest thinning. As a result, it may be possible to counteract the conversion of forests to corn or barley fields on lands that are generally not suited to agricultural production (pers. obs.; Snook 1993; Soto Nunez and Vazquez Garcia 1993; Gonzalez de Castilla 1993). This strategy is accomplished by informing *ejido* communities of the values of recreating forests on lands that have been cleared, and providing tree seedlings and follow up support for reforestation. The first sites were reforested under this program in the summer of 1997. Over time, the trees that are planted will provide short-term income through the marketing of Christmas trees, and additional long-term income through the marketing of other forest products. The reforested areas will also be a sustainable source of subsistence wood for fuel and other domestic uses, thereby reducing the pressure on the remaining oyamel forests. Forest conservation and habitat protection goals will be achieved cooperatively, as the *ejido* communities participate in establishing a viable alternative to continued thinning and logging of the natural forests to obtain the wood they need.

Introduction and problem description

This paper describes some of the problems associated with deforestation in the El Rosario/Cerro El Campanario area (Michoacán, Mexico), presents the La Cruz Habitat Protection Project as an example of one solution that addresses these problems, and discusses the benefits of reforestation and its relationship to the conservation of forest habitat. Other studies of the problems caused by deforestation have suggested the development of alternatives, such as intensively managed forestry sites for extractive wood uses, as a way to shift the pressure away from the few areas of remaining oyamel forests (see, for example, Snook 1993). However, reforestation has not been widely implemented as a forest conservation strategy in the monarch areas, for a number of reasons. These reasons include inadequate resources and technical support for reforestation, and a lack of understanding and/or acceptance of this approach by the people who own the land, the *ejidatarios*. The La Cruz Project may be the first such project that focuses specifically on creating usable forest stands on *ejido* landholdings that have been cleared and converted to agricultural uses.

There are at least three categories of problems or effects associated with past deforestation and current forest practices: 1) resource sustainability and economic issues affecting the *ejidatarios* living in the area; 2) ecological effects on the forest ecosystem, including effects on overwintering monarchs; and 3) physical watershed effects.

Resource sustainability and economic issues

One of the most critical problems caused by deforestation is the loss of a sustainable natural resource base for the *ejidatarios* who inhabit the area. This loss has both ecological and socio-economic implications. The reforestation approach being carried out by the La Cruz Habitat Protection Project, as discussed in this paper, is presented as a strategy to address these effects.

The oyamel fir forest (*Abies religiosa*) which comprises the monarch butterfly sanctuary at Cerro El Campanario is surrounded by extensive areas where the forest was cleared and subsequently converted to fields used for the growing of corn and other crops, such as barley (pers. obs.; Snook 1993; Soto Nunez and Vazquez Garcia 1993; Gonzalez de Castilla 1993). The human inhabitants of this area, members of the El Rosario *ejido*, are primarily subsistence agriculturalists. They need both fields for growing food crops and grazing, and forests to supply their wood needs and supplement their meager incomes. However, when forests were initially cleared for exploitation of timber resources, reforestation of the cleared lands was not accomplished. As a result of the extensive change in vegetative cover in the El Rosario/Cerro El Campanario area, the only wood source available to the *ejidatarios* is the remaining oyamel forest within and adjacent to designated sanctuaries and buffer areas. As a result, forest thinning continues.

These problems are not unique to Ejido El Rosario. Deforestation, forest thinning, and land conversion to agricultural uses threaten other monarch colonies and sanctuaries as well. Conservation of this oyamel forest ecosystem, the monarch overwintering habitat, and preservation of the endangered biological phenomenon of the monarch migration (Brower and Malcolm 1991), are difficult if not impossible to address without reversing the trend of converting forest lands to agricultural fields. It is essential that any viable solution provide local residents, who own these lands, with an alternative to continuing to thin the remaining oyamel forest in order to meet their needs for subsistence wood and income from the sale of logs.

The *ejido* communities in many of the monarch areas have no viable alternatives to exploiting the remaining natural forests for their domestic wood uses. Substantial amounts of wood are used on a daily basis for domestic purposes and to supplement household income by producing charcoal or building materials and selling firewood. Although figures on the amount of local fuelwood use by residents of the El Rosario *ejido* are not available, Snook (1993) presented estimates of domestic fuelwood consumption in the fir forest zone in the Mexican state of Veracruz at about 15 tons or 35 m^3 per year per household. She concluded that if similar levels of consumption occurred in the monarch areas, it would equate to a total consumption of 40,000 average-size fir trees per year by *ejidatarios* living in the areas surrounding the Chincua, Chivati-Huacal, and Cerro El Campanario sanctuaries. Since many of the families living in the El Rosario area are totally dependent on wood as a fuel for cooking and heating, reforestation of some of the cleared lands may be the only way to provide a sustainable local supply of wood for domestic uses in a manner that allows the remaining natural fir forests to be preserved.

Although lands where fir and mixed fir-pine forests were cleared are currently used to produce agricultural food crops, this is not necessarily the best use of the land from the standpoint of the *ejidatarios*. Because of the marginal nature of the soils and climatic conditions, corn crops grown on steep mountain sites have relatively little subsistence or cash value, producing only a fraction of what can be grown on more suitable agricultural fields. Shifting a portion of these steep lands to the production of trees for domestic wood consumption and income will need to be accompanied by a combination of more intensive agricultural production on more suitable fields (e.g., flatter land, with better soils), and use of income from tree growing sites to purchase corn that may have otherwise been produced on the reforested lands.

Effects on monarch habitat

In addition to the problem of a declining natural resource base for the *ejidatarios*, ecosystem changes associated with deforestation threaten the long-term survival of the monarch colonies that overwinter at Cerro El Campanario. Deforestation is directly associated with the loss of existing and available forest habitat for overwintering monarch populations. Furthermore, thinning of the remaining areas of oyamel forests, while a somewhat less definitive agent of habitat loss, may render some areas of forest unsuitable as habitat for successful overwintering by monarchs. It has been shown that forest thinning, where individual trees or limbs are selectively harvested, causes important changes in the microclimate, particularly wintertime temperature and moisture regimes, which adversely affect the overwintering butterfly colonies (Brower 1996; Alonso et al., these proceedings). These adverse effects include increased mortality due to exposure to freezing weather conditions and increased predation, as well as microclimate effects that trigger changes in the timing of spring migrations, leaving migrating butterflies susceptible to adverse early season conditions along their northward migration route.

Another adverse effect is the loss of a forest type and ecosystem which cannot be re-created through reforestation or intensive forest management. The oyamel forest ecosystem, which is the only suitable overwintering habitat for the entire migratory monarch population that breeds throughout eastern North America, is a relict forest ecosystem (Rzedowski 1978 in Snook 1993). The contemporary distribution of this forest type may be attributed to Pleistocene glaciation and the climatic changes that occurred over the 10,000 years after the glaciers receded. Today, these oyamel forests exist as islands on mountain tops in the transvolcanic belt of Michoacán and México States and a few other areas of Mexico. It has been estimated that only 40–50,000 hectares of oyamel forest remain in Mexico, and this estimate is based on an inventory that is over 20 years old (Snook 1993). Snook concluded that the patchy distribution and limited extent of the oyamel forest may make it the most vulnerable forest type in Mexico to the effects of deforestation.

Watershed effects

Adverse watershed effects of the extensive deforestation and past forest management practices include changes in hydrologic regimes and geomorphologic processes, affecting the condition of water resources and aquatic ecosystems. These effects were apparent during field observations of the severely aggraded condition of streams draining the El Rosario area (pers. obs. 1997). These streams are tributaries of Arroyo La Hacienda and the Rio Zitacuaro. The sediment load in this river system is out of balance with the capacity of the streams to transport sediment. This has resulted in substantial shallowing and widening of the stream channels, or aggradation, due to the excess of stored sediment. Combined with the effects of removing streamside riparian forests, this has negative impacts on aquatic life which rely on the habitat within streams (Waters 1995). It can also lead to increased flooding and stream bank erosion that affects human uses of productive agricultural land adjacent to the streams. It was also observed that, during seasonal runoff events, the chronic soil erosion and sediment pollution results in highly turbid water in the streams. This condition further affects the suitability of water resources for human and aquatic life uses (Newcombe and MacDonald 1991). By contrast, the streams flowing from forested areas in the upper basin produce clear water during runoff events.

There are several sources of the sediment pollution observed downstream of deforested areas. In other areas subjected to intensive timber harvesting, studies of sediment budgets have shown that logging roads are often the major source of sediment delivered to streams (Swanson et al. 1982; Rashin et al. 1997). Severely eroded logging roads that have not been properly designed and maintained to control drainage are common throughout the area, especially in the mixed fir-pine forests and pine-oak forests (pers. obs.). They are probably one of the major sediment sources in this drainage basin. Other sediment sources observed in the basin include landslides and gully erosion in the steep uplands where forests have been cleared, as well as surface erosion from agricultural fields. Degradation of soil resources due to erosion and depletion of soil nutrients are additional adverse effects of deforestation and conversion of forests to agricultural fields, that have long-term implications for the future of both forest and agricultural productivity in the area. Furthermore, depleted soils commonly require chemical additives to sustain even biennial or triennial corn crops. If these additives are used improperly, excess nutrients or pesticides can contribute to adverse water quality conditions downstream of the agricultural fields.

A Solution: the La Cruz Habitat Protection Project

The La Cruz Habitat Protection Project is taking steps to reverse the trends of forest conversion to agricultural fields and the continuing thinning of remaining mature forest stands. This is accomplished by shifting marginal agricultural lands back to forested lands that will provide usable resources and other economic benefits to the landowners. The project is focusing on reforestation of *ejido* lands where natural forests have been cleared for agricultural uses, as well as to exploit timber resources. In the El Rosario area, such plots of land are typically owned by individual *ejido* families. The focus on reforestation of cleared agricultural fields distinguishes this project from government-sponsored tree planting efforts in the Cerro El Campanario area. The government programs have tended to direct their efforts on planting seedlings in existing oyamel or mixed forest stands in order to supplement natural regeneration (pers. obs.). The La Cruz Project relies on voluntary participation by *ejido* landowners who have come to understand the benefits of growing trees on their lands for their own use. The degree of participation is determined by the number of seedlings available and the interest on the part of individual *ejidatarios*. The purpose of these reforestation efforts is to provide El Rosario residents and the residents of other *ejido* communities with an alternative to relying on remaining areas of natural forests, such as the monarch habitat areas, for their wood. The approach being used by the project was developed through experience gained by working with *ejido* communities on reforestation projects in the Santa Clara del Cobre area (Michoacán, Mexico).

The La Cruz Project is supporting reforestation at El Rosario in several ways. These include developing community awareness about the reforestation alternative, provision of seedlings, logistical and technical support for tree planting, and follow-up support and training for the long-term management of the reforestation sites. Before the first reforestation site was planted, substantial efforts were devoted to informing *ejido* leaders and individual landowners of the potential benefits of reforestation. The forest engineer who had been working with the *ejido* participated in this informational effort. As the *ejido*'s key community leaders became familiar with the reforestation concept, they assisted by obtaining the cooperation and participation of individual landowners.

Oyamel fir and pine seedlings are raised for the La Cruz Project at its nursery near Santa Clara del Cobre in central Michoacán. These are supplemented as needed with seedlings obtained from local nurseries in the Angangueo area, and delivered to the participating landowners at El Rosario. Locally-obtained oyamel seed is used to grow the reforestation stock for this species, in order to preserve the genetic properties of local forests. Because of special requirements, successful nursery culture of oyamel seedlings is more difficult than that of other tree species. This may explain why many other nurseries in the area focus on raising cedar. However, planting cedar does not offer the same benefits for ecosystem restoration and resource sustainability. In fact, planting the wrong trees works against the goals of restoring soils and forest ecosystems, because they are not a natural component of the high altitude, fir-pine forests characteristic of the El Rosario area (Soto Nunez and Vazquez Garcia 1993).

Monetary and in-kind contributions from individuals in the United States and Mexico have funded the La Cruz Project. These contributions make it possible to propagate the seedlings used by the project in its reforestation efforts. The contributions also cover the costs of transporting the seedlings to the sites where they are planted, and help pay for assistance with planting on individual sites. The planting provides an opportunity to train landowners, local workers, and volunteers in proper spacing and tree planting techniques. All this work must be accomplished during the brief rainy season from July through late August, which is the critical time for planting. Landowners are also instructed in the proper care of the young seedlings after they are planted. For example, the importance of protecting seedlings from damage by grazing animals is emphasized. The project continues to work towards the goals of sustainable forest management by providing follow up support for managing the woodlots established through these reforestation efforts. This includes monitoring tree survival and growth at the reforestation sites, and coordinating necessary maintenance activities such as re-planting and fencing to protect the trees from livestock damage.

After successfully establishing people-to-people relationships and increasing community awareness of the benefits of reforestation, the first sites were planted with fir and pine trees under this program in July and August of 1997. Four separate plots of land owned by members of Ejido El Rosario were reforested. The four plots totaled approximately 3.5 hectares. The location of the 1997 reforestation sites is shown on a map of the area in Figure 1. This map also shows the extent of forest cover, based on analysis of 1990 aerial photographs of the area, and the approximate boundaries of the Cerro El Campanario monarch sanctuary and associated buffer zone. Roads and the major streams draining the area are also shown in Figure 1.

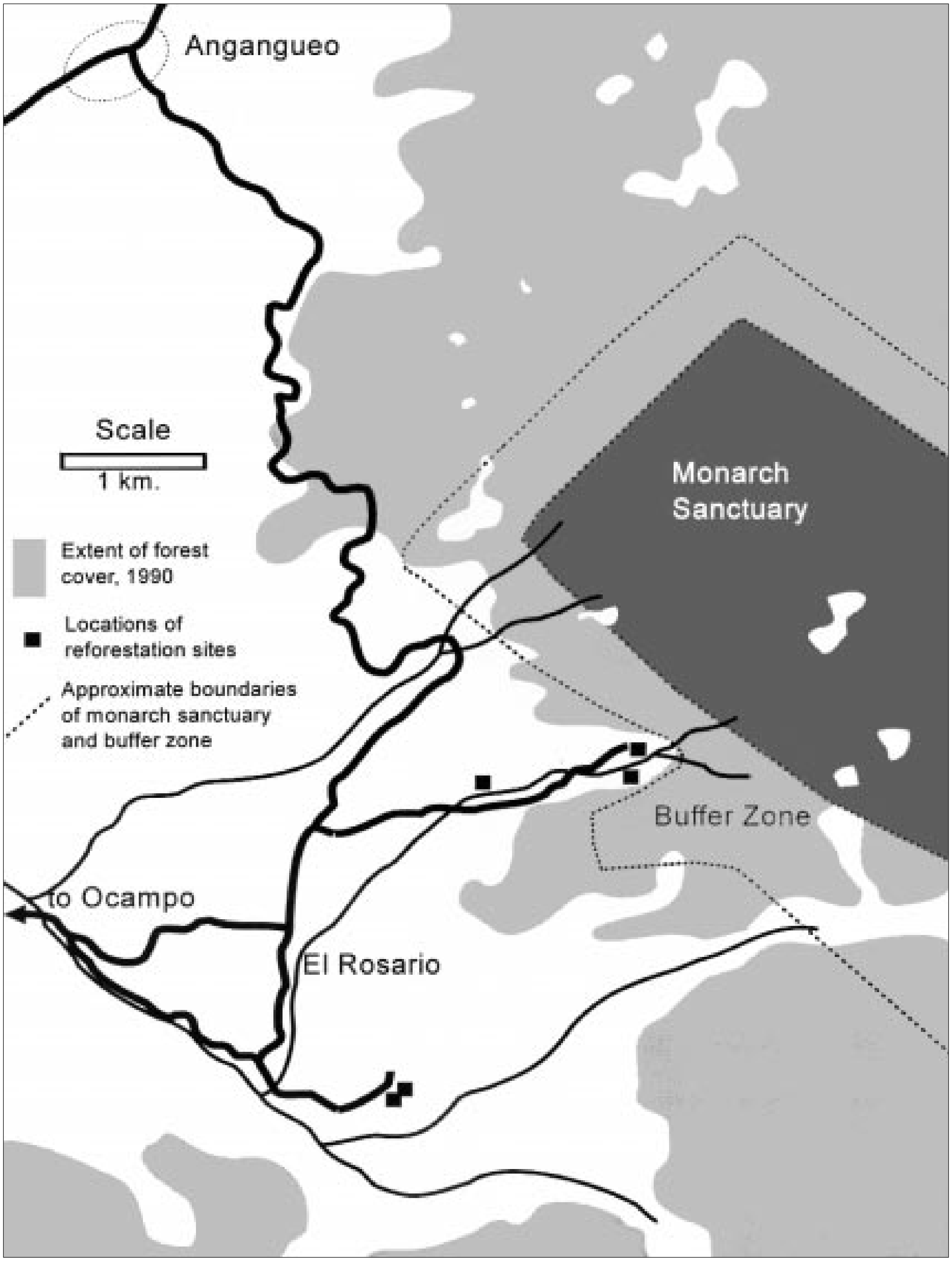

Figure 1. Map of El Rosario area, showing reforestation sites planted in 1997.

Some of the reforestation sites are located in close proximity to existing areas of mature forest stands within the buffer zone established around the monarch sanctuary (Figure 1). Although planting sites within or adjacent to mature forests and established buffer zones may eventually play a role in ecosystem restoration, the focus of the La Cruz Habitat Protection Project is not on directly restoring the ecosystem functions of the sanctuaries or buffer areas. Its focus is on reducing the pressure on these areas to supply the local demand for wood. The philosophy of the project is to provide reforestation assistance to any *ejidatario* who is interested in reforesting lands which have been previously cleared. It is our belief that by maximizing the number of people who realize benefits from reforestation, other landowners from other *ejidos* in the area will be encouraged to reforest their lands. Landscape-scale changes may be achieved over time if enough landowners participate. As an indication of the level of interest, it is encouraging to note that during the first planting season, the demand for seedlings exceeded the amount that the La Cruz Project could supply.

Conclusions: Reforestation as a strategy for forest conservation and ecosystem restoration

The La Cruz Project is not intended to be an attempt to recreate natural forests. Once natural forests are cleared by logging or severely altered by thinning, re-establishment of these complex ecosystems through human intervention may not be an achievable goal. Reforestation, as practiced in this project, is a strategy for conserving the remaining natural oyamel and mixed fir-pine forests by establishing alternative sites for extractive forest uses by local residents, who are also the landowners of the monarch sanctuaries and buffer areas. The intent is to assist the *ejidatarios* by involving them in saving the forest that provides a buffer for the overwintering monarchs, a biological heritage they are committed to preserving. Cooperative preservation of their forests and the monarch habitat will be facilitated when the local people, who are heavily reliant on wood from forest trees and who have historically used the oyamel forest, see that they have a viable alternative to continuing to log and thin the forest.

In addition to conserving remaining forests and butterfly habitat, reforestation will indirectly contribute to ecosystem restoration on a landscape scale, if extensive areas are planted and maintained as woodlots. This includes restoration of the hydrologic balance and soil conditions within the drainage basin, as well as restoration of some elements of the natural vegetation communities. However, these aspects of ecosystem recovery will require a high level of participation by local landowners over many years. Stewardship values, which have been instilled in the farming culture of the *ejidatarios* over generations, will be strengthened and given a means of expression through learning a new way to meet their needs for forest resources. Expression of these deep-seated cultural values will make ecosystem restoration possible.

How will it be possible to achieve the high level of participation among local landowners that will be necessary to advance forest conservation and ecosystem restoration goals? We believe that reforestation offers direct economic benefits to the *ejido* members who participate. The establishment and sustainable management of woodlots provides a long-term source of forest products for subsistence needs and opportunities for income for those families who invest in reforestation. A system of integrated sustainable forest management is illustrated in Figure 2. This system provides for both subsistence wood uses and a continuing source of income from forest products.

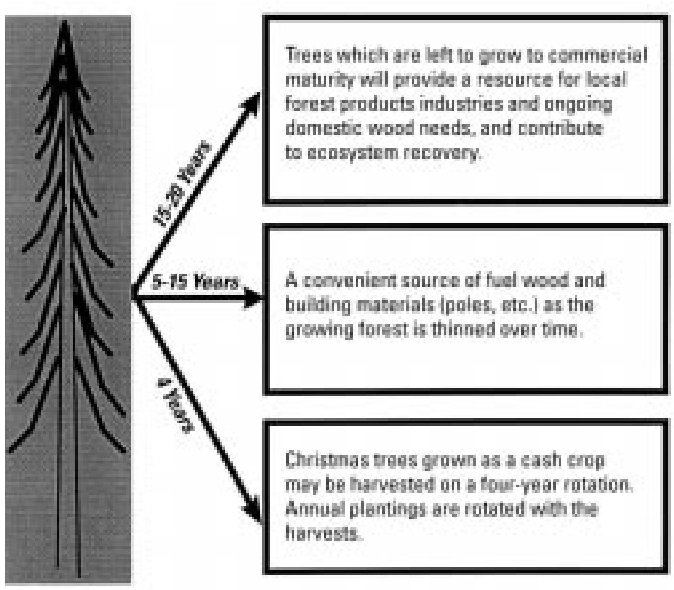

Figure 2. Integrated sustainable forest management of reforestation sites is the long-term goal.

As shown in Figure 2, income will be produced in four years from oyamels and pines that are planted for Christmas trees. Ideally, a system of harvesting Christmas trees on a four-year rotation can be established, whereby a portion of the trees is harvested each year. The trees that are harvested are replaced by annual supplemental plantings of new seedlings. In this way, a continuous income stream can be established. After about five years, wood will be available for subsistence harvesting to supply needs for domestic firewood uses and charcoal production. The convenience of having a source of wood for domestic uses on their own property, rather than having to continually go up into the forest to harvest wood, is an additional incentive for landowners to participate in reforestation. Over a period of five to fifteen years after the initial planting, necessary thinning of trees will provide a source of poles, fence posts, and small dimension lumber. In fifteen to twenty years, trees that are allowed to grow to a more mature size will be available for lumber production. Where pines are planted, there will be opportunities for resin extraction as an additional source of income. The establishment of mixed-age stands and understory vegetation on reforestation sites may also provide important genetic resources for ecosystem restoration, and over time will promote recovery of healthy soil conditions and hydrologic balance. It is a long-term goal of the project that participating landowners will take an integrated approach such as this to managing their reforestation sites.

Effective community organization will be the key to developing ways to market Christmas trees and other forest products, in order to optimize income production as a benefit to landowners who invest in reforestation. The pre-Christmas tourists that annually come to the monarch preserve at El Rosario can be provided with opportunities to buy sustainably-produced Christmas trees as a way to support forest conservation. Woodlot owners who manage part of their trees for longer rotations and produce commercial size timber can eventually develop local forest products industries to supply local needs for building materials, and promote a value-added approach to using trees for income.

Although most of the *ejidatarios* at El Rosario practice small-scale farming to feed their families, sites targeted for reforestation are not well-suited to producing corn or other crops for income or subsistence needs, due to climatic conditions, steep slopes, and highly erodible soils with marginal agricultural productivity. The need to use chemical fertilizers for agricultural crops further reduces the economic viability of farming these lands. Yet these same lands are ideally suited to growing native species of forest trees. Given the inherent limitations for agricultural production, government incentives to plant trees and production of Christmas trees as a cash crop can provide several times as much income as a corn crops grown on the same land (Soto pers. comm. 1997; Contreras Telles pers. comm. 1997). However, because the beginning of a sustainable income stream from forest products will be delayed a few years, the shift to growing trees is a long-term investment and a major decision for landowners. It will be necessary to use some of this income to replace the food previously obtained from subsistence farming, and many families will continue growing food crops on part of their land, no matter how marginal the productivity. At the same time, flatter lands in the area that are more suited to growing corn and other crops will need to be farmed more intensively, suggesting the need for a more strategic approach to establishing agricultural fields and systems for distributing the agricultural production. Such organizing and planning at the community level can only serve to advance the goals of forest conservation and ecosystem restoration.

The La Cruz Habitat Protection Project is made possible by the support of the people of El Rosario and outside volunteers and contributors. The project has the capacity to provide tens of thousands of seedlings for reforestation. The Michoacán Reforestation Fund is a volunteer-based, non-profit corporation that has recently been established to support forest conservation activities, and is providing administrative and fund-raising support for the La Cruz Project. The objective for future years is to greatly increase the level of participation by *ejido* members and to expand the ability of this volunteer-based project to support reforestation through enhanced fund-raising efforts. The goal of the La Cruz Habitat Protection Project and the Michoacán Reforestation Fund is quite simple. Any *ejidatario* who has decided to reforest his or her land should be provided with the seedlings and other support needed to make reforestation a reality.

Acknowledgments

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Monarch conservation efforts of the Texas Parks and Wildlife Department

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Abstract

Since more than 97% of Texas is privately owned, wildlife management is conducted by landowners desiring a sustained economical use of their property. Commercial hunting enterprises, combined with sustainable agricultural practices, provide the incentive for much of the habitat conservation in the state. One of the greatest threats to wildlife habitat in Texas today is the subdivision of large land holdings into smaller tracts. Changes in estate tax structure, improvements in maintaining production agriculture on suitable land, and controlled, sustainable commercialization (i.e., hunting and nature tourism) of key resident wildlife may slow this trend (DeGraaf and Rappole 1995). Cooperative efforts involving multiple landowners within managed areas such as wildlife cooperatives and associations, county-planning units, and water districts must become commonplace if strategies for the future of wildlife in Texas are going to be successful. With the passage of Proposition 11 in 1995, landowners can now retain their agricultural property tax valuation if their land use changes to active wildlife management. This will ultimately have a positive effect on wildlife as small land holdings, forced to graze livestock for tax purposes, receive much needed deferment. The techniques for managing many nongame species are now available through the Texas Wildscape Program, administered by the Texas Parks and Wildlife Department. The Texas Monarch Watch Program as well as research concerning the population dynamics of monarchs in Texas have provided avenues for outreach, education, and investigation into the needs of monarchs in the state.

Wildlife conservation in Texas

Texas encompasses over 80 million hectares within 10 distinct ecological regions. From Chihuahuan Desert, which receives about 15 cm of annual rainfall, to Eastern Deciduous Oak Forests, which receive about 150 cm, over 97% of this land area is managed by private landowners. Within the major flyways for monarch butterflies are found cypress swamplands, oak-pine timber lands, tall and short-grass prairie, oak-juniper limestone hills, desert scrub, and coastal salt marshes. This diversity of habitat and associated land use challenges wildlife managers when developing common goals for target species. Private/public partnerships are essential for successful wildlife management in Texas. Tools such as cooperative wildlife management associations, tax incentives, nature-based tourism, and other sustainable practices are common strategies to address wildlife (a public resource) concerns which occur on privately managed habitats. Especially for migratory wildlife such as waterfowl and neotropical songbirds, it is vitally important for government agencies to invest in private land incentives in order to manage the habitat on which these species depend. Cooperative joint ventures for waterfowl, and initiatives such as Partners in Flight for neotropical songbirds are models for how to approach monarch butterfly conservation along its entire migratory path.

Although Mexico and Texas share similar biological resources, differences in legal, social and economic structure are obstacles in applying similar conservation strategies across the border. For example, we know that while most of the land in Texas is privately owned, over 80% of the population lives in urban areas. Although many urbanites do not necessarily hunt or fish, many of them simply enjoy being outdoors and seeing wildlife. In fact, while the number of hunters has stabilized, or even declined in some cases, the demand for "non-consumptive" outdoor activities has increased. Today, nature-based recreation is the fastest growing segment of the travel industry in the US, averaging a 30% increase each year since 1987, with sales totaling $238 billion in 1994 (Task Force on Nature Tourism 1995). Lease-hunting for white-tailed deer (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus*), and game birds such as wild turkey

(*Meleagris gallopavo*) and bobwhite quail (*Colinus virginianus*) continue to be a major financial incentive for landowners to maintain habitat throughout much of Texas. Many South Texas ranches sell trophy white-tailed hunts in excess of $5,000 per hunter. Several hunting operations are now interested in obtaining supplemental income by integrating wildlife photography and birding tours for relatively little investment. One ranch in particular is interested in providing guided tours to view monarchs roosting in a riparian area on their journey south in the fall. Well-planned niche marketing and infrastructure are necessary to adequately promote a unique wildlife experience, and accommodate the needs of mostly retired, well-educated visitors.

Texas Monarch Watch

The Texas Monarch Watch Program was initiated by Dr. Bill Calvert in 1993 to: 1) learn as much as possible about monarch migration through Texas using volunteer observers, and 2) instill in participants an appreciation of monarch biology and nature in general (Calvert and Wagner this volume). The program is modeled after the national Monarch Watch (Taylor this volume), with special emphasis on research and conservation on monarchs in Texas. Two "watches" are conducted each year—one in spring and another in the fall. Calendars and monarch tags are distributed to about 1,100 participants. A Monarch Watch Hotline is available for toll-free reporting of monarchs passing through the state each spring and fall. Results are compiled and reported in a newsletter sent out twice each year. In addition to participation by the public, seventeen sites managed by the Texas Parks and Wildlife Department (TPWD) are also involved. These sites are comprised of state parks and wildlife management areas distributed throughout the state. Finally, TPWD is sponsoring research on the reproductive success and population dynamics of the monarch in Texas. From this work, investigations in the effect of the red imported fire ant (*Solenopsis invicta*) on survival of larval monarchs have been initiated. In addition, monarch distribution and seasonal abundance can be estimated and correlated with milkweed (*Asclepias* spp) use (Calvert 1997).

Using reports sent in by Texas Monarch Watch volunteers, we have identified two primary migration routes through Texas: the central route and the coastal route (Calvert and Wagner 1998, this volume). In order to inform private landowners of land management practices beneficial to monarchs, technical guidance should be provided within the migratory corridors for monarchs.

Working with private landowners

The Texas Parks and Wildlife Department employs 10 Technical Guidance Biologists throughout the state to work directly with private landowners in developing voluntary wildlife management plans for their property, free of charge. An additional 200 field biologists are engaged in regulatory, research, and wildlife management area duties. Many of these individuals also work one-on-one with landowners on a regular basis. Seminars, workshops, and mass media such as television, radio, and publications are commonly used to reach more than 10,000 land managers on more than 4 million hectares of private land annually. In addition, over 80 wildlife management associations encourage cooperative management of small tracts to benefit wildlife on a larger scale. Incorporating the needs on monarchs and other nongame wildlife is simply a matter of providing the information necessary to educate landowners, and identify specific practices that will benefit these species, consistent with overall goals for the property.

Milkweeds such as *Asclepias latifolia*, *A. asperula*, *A. oenotheroides*, and *A. asperula* are generally considered weed species thriving on overgrazed or otherwise disturbed sites. These milkweeds are important host plants for monarchs in Texas, and should be encouraged where appropriate. Nectar plants such as *Liatrus* spp, *Eupatorium* spp, and *Verbesina* spp are also important components for monarch habitat, and should be allowed to increase as needed. Research is needed in the area of milkweed and nectar plant seedling ecology and physiology in order to determine those factors that promote their establishment. Mowing and grazing practices, as well as prescribed burning are common land management techniques that may benefit many of these and other plants when applied correctly. Many times, a diversity of forb species, including those beneficial to monarchs, are indicative of early successional habitats that benefit game birds such as bobwhite quail and mourning dove (*Zenaida macroua*). Managing for these and other important game species will benefit monarchs and other nongame wildlife as well. The conversion of "improved" pastures of introduced grasses such as bermudagrass (*Cynodon dactylon*) back to native vegetation is another long-term strategy that landowners may consider as larger ranches are subdivided and livestock grazing is no longer the main land use. The Texas Wildscape Program, initiated by TPWD in 1993, encourages the use of native plants to restore wildlife habitats in urban, suburban, and rural settings. Over 6,000 Texas residents are participating in this statewide program. Decreased use of fertilizers and herbicides will also enhance native vegetation, which tends to increase as these costly inputs decrease.

Today, habitat fragmentation is occurring rapidly in suburban areas as development expands into former farm and ranch operations. Resource managers must develop habitat restoration plans as a means to link open space with larger tracts of habitat along common corridors such as drainages and fence lines. Under these conditions, corridors or “linear habitats” are extremely important. Fence lines, drainages, and roadways are all potential linear habitats that could be linked together to form mutual corridors for wildlife traveling between remaining blocks of habitat. In response to a new awareness of wildlife needs in suburban settings, a number of new housing developments in San Antonio are now incorporating wildscaping techniques in new, more environmentally-friendly neighborhoods. To recognize outstanding examples of wildlife habitat management on private ranches, the Lone Star Land Steward Award Program was created to select one winner in each ecological region of the state as well as one overall winner for the landowner demonstrating the highest standards of environmental excellence.

Proposition 11

In 1995, Texans voted to pass Proposition 11, allowing landowners to retain their agriculture tax valuation if the land use is changed to active wildlife management. This proposition amends the Texas Constitution to permit open-space land used for wildlife management to be taxed as agriculture land. The law only applies to landowners currently receiving an agriculture tax valuation, and wishing to switch to wildlife management use. Regional guidelines are being developed by the Comptroller in cooperation with TPWD and the Texas Agriculture Extension Service. These guidelines include general management practices that benefit a wide array of nongame species, with an appendix referring to habitat restoration using beneficial native plants specific to each area of the state. Land eligible for shifting to the wildlife tax evaluation must be actively managed for wildlife in at least 3 of the following 7 ways to qualify: 1) habitat control, 2) erosion control, 3) predator control, 4) providing supplemental water, 5) providing supplemental food, 6) providing shelter, and 7) conducting population census. This bill was supported by a broad coalition from private property rights advocates to environmental groups, and will have positive impacts on wildlife in the state (Comptroller 1996).

Conclusion

If successful wildlife management is to continue into the 21st century, private/public partnerships are essential in a private land state such as Texas. In addition to changing land use and threats from habitat fragmentation, changing values toward wildlife and associated management issues will challenge wildlife professionals to seek new strategies for reaching new constituents. In 30 years, Texas’ population will double to over 25 million, and increasingly urban, ethnic populations will play an important role in the future of wildlife in the state. Will these new user groups hold the same values present today? As we approach strategies for managing for wildlife diversity, we need to also consider cultural diversity. I predict that Texas will be learning from Mexico in this regard.

Finally, the term “conservation biology” has been used a number of times at this conference. Ideally, this discipline involves wildlife biologists, botanists, mammalogists, ornithologists, herpetologists, entomologists, land managers, indigenous peoples, economists, geographers, politicians, and a host of other resource professionals cooperating to develop solutions to conservation issues. A partnership or team must be formed to work more effectively in the creation of long-term solutions to conservation issues. As in all successful teams, we must respect the positions of all team members. The biologists job is to provide facts and help educate, but not necessarily to make the ultimate decisions of resource policy—that task is left to other team members who have leadership roles at the local, state, and federal levels.

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Conservación y restauración forestales: retos y oportunidades a partir de un estudio sistémico de la demanda de productos forestales

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Síntesis

Se presenta una metodología que trata de armonizar las necesidades de conservación y restauración forestales con las múltiples demandas de los pobladores e industrias locales sobre los productos forestales. La metodología parte de un estudio integral de la dinámica de uso regional del bosque e incluye: a) caracterización del sistema forestal; b) determinación del número e intensidades de consumo de los usuarios de productos forestales, incluidas la demanda doméstica y de la pequeña y gran industria; c) oferta del recurso forestal, por principales géneros; d) impacto ecológico de la demanda de productos, y e) selección de alternativas. Esta metodología se ha aplicado con éxito en la "Región Purépecha" del estado de Michoacán y puede replicarse en el área de la mariposa monarca.

Introducción

Los esfuerzos de conservación y restauración forestal frecuentemente fracasan por no entender las demandas concretas que los pobladores de las áreas boscosas —incluidas las áreas naturales protegidas— ejercen sobre estos recursos.

En las áreas con potencial forestal comercial se han manejado los bosques como abastecedores de materia prima para las grandes industrias forestales (aserraderos, astilladoras). Esto ha significado concentrar los esfuerzos y la investigación en aquellas especies que tienen valor en el mercado de la gran industria —específicamente los pinos— y en los establecimientos de gran envergadura. Asimismo, la planeación ha respondido, por lo regular, a la oferta de los recursos forestales más que a un análisis detallado de la demanda regional de estos últimos productos. La población local, dueña mayoritaria de los bosques, y sus demandas concretas sobre los recursos quedan generalmente fuera de este esquema. La suposición implícita es que la demanda de los pobladores locales: a) representa una pequeña fracción de la demanda de productos y por lo tanto su impacto es negligible, y b) representa sectores muy marginales desde el punto de vista económico.

Se verifica de este modo una contradicción que lleva inevitablemente a conflictos por el uso de los recursos forestales. La situación es particularmente preocupante en nuestro país, donde 80% de los bosques son propiedad de ejidos y comunidades, se observan altas densidades de población —particularmente en los bosques templados de la parte centro-sur de México—, existe un bagaje indígena ligado al aprovechamiento integral de los recursos naturales, y la pobreza y falta de empleo en el campo son generalizados.

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En este trabajo se presenta una metodología que trata de armonizar las necesidades de conservación y restauración forestales con las múltiples demandas de los pobladores e industrias locales sobre los productos forestales. Parte medular de esta metodología es caracterizar adecuadamente el *sistema forestal*, que incluye a los diferentes agentes —comerciales y no comerciales, pequeñas y grandes industrias— que hacen uso del bosque, los productos que esos agentes elaboran, sus interacciones geográficas y el impacto que cada uno genera sobre la vegetación y otros recursos. Ilustraremos esta metodología con un estudio de caso en la región purépecha del estado de Michoacán.

Como demostraremos en las siguientes secciones, las conclusiones a las que se llega mediante este tipo de análisis y por tanto el tipo de políticas apropiadas para atacar los problemas de fondo son muy diferentes a las del enfoque forestal tradicional.

Área de estudio

La región purépecha se localiza dentro de la provincia fisiográfica denominada Sistema Volcánico Transversal o Cordillera Neovolcánica, y ocupa la porción centro-noroeste del estado de Michoacán. La topografía de la sierra es inclinada, y la geomorfología compleja, con elevaciones desde los 1,050 m en los valles hasta los 3,860 m en las partes más altas (cerro de Tancítaro). Para nuestro estudio consideramos un total de 16 municipios divididos en tres subregiones: **La Cañada**, que comprende el municipio de Chilchota; **La Meseta**, que comprende los municipios de Charapan, Cherán, Nahuatzen, Paracho, Los Reyes, San Juan Nuevo, Tancítaro, Tingambato, Uruapan y Tangancícuaro (excepto Noroto), y **Lago de Pátzcuaro**, que comprende los municipios de Erongarícuaro, Pátzcuaro, Quiroga y Tzitzuntzan. Incluimos en esta región el municipio de Salvador Escalante, que comprende la cuenca del lago Zirahuén, y los poblados de Capula, municipio de Morelia, y Zipiajo, municipio de Coeneo, por su importancia en la producción alfarera.

Con esta demarcación, nuestro universo de estudio abarca 16 municipios con una población de 512,903 habitantes, según el censo de 1990 (INEGI, 1991), y una superficie aproximada de 481,711 hectáreas (INEGI, 1990). La población rural pertence mayoritariamente a la etnia purépecha y enfrenta fuertes problemas de marginación, pobreza y migración. Los productos forestales cumplen un papel preponderante en la economía regional, con una importante industria forestal instalada y una intensa actividad artesanal ligada al trabajo de la madera y el consumo de leña. Se estima que unas 150,000 personas basan su economía en la producción artesanal.

La región ocupa una de las áreas de mayor interés silvícola de la porción centro-norte del estado de Michoacán. Estos bosques son altamente diversos para su tipo e incluyen diez especies de *Pinus* y 12 de *Quercus*, entre muchas otras especies forestales. No obstante su importancia natural, económica y social, a partir de 1940 se ha verificado un rápido proceso de deterioro ambiental. Como factores o agentes de este deterioro se pueden considerar el cambio de uso del suelo y el clandestinaje de madera, así como la presencia de plagas, enfermedades, incendios, apertura de caminos y tendido de líneas de transmisión. En la actualidad, el paisaje ambiental refleja cambios evidentes, causados principalmente por un tipo de manejo extractivista de los bosques enfocado exclusivamente a la producción de madera en rollo. Se estima que en los últimos 35 años se ha perdido aproximadamente el 50% de la superficie arbolada que se tenía en la década de los cincuenta (Mas-Porras, 1992). Por otro lado, las especies vegetales que todavía habitan esta zona se encuentran sujetas a un proceso de deterioro en calidad, caracterizado por una reducción en la diversidad genética y una mayor propensión al ataque de plagas, enfermedades e incendios (Alvarez-Icaza *et al.*, 1993). Para 1993, a partir del estudio realizado por Bocco *et al.* (1997), se estima una superficie forestal de 225,000 ha, incluidas tanto las áreas con vegetación de tipo comercial como las zonas de bosque degradado y no comercial. Se estima que de 1987 a 1993 se perdieron 22,123 ha, esto es, una desforestación anual promedio de 3,160 ha (Masera *et al.*, 1997).

Cuadro 1 **Evolución de la superficie forestal en la región purépecha, 1987-1993**

Subregión	Superficie total	Superficie forestal[a] 1985-1988	Superficie forestal[b] 1993	Diferencia 1987-1993
Meseta	344,143	194,880	175,532	19,348
Cañada	45,820	16,060	16,060	0
Lago	91,748	36,665	33,890	2,775
Total	481,711	247,605	225,482	22,123

[a] Fuentes: Subregión Lago, Toledo *et al.* (1992), subregiones Meseta y Cañada, Caro (1987) e INEGI (1988). En varios municipios se subestima la superficie de bosques sin valor comercial.

[b] Fuente: Gerardo Bocco *et al.* (1997) incluyen todos los bosques comerciales y no comerciales de la región. Para Chilchota se eliminaron 9,362 ha, que corresponden a bosques de encino sumamente degradados.

Método

Entender la dinámica de la demanda de productos forestales y su posible impacto en los bosques de la región implica cinco pasos importantes:

1 Caracterización del sistema de productos forestales

Aquí se determinan las entradas, salidas, componentes y principales interrelaciones del sistema en términos de los flujos de productos forestales. La oferta de madera constituye las entradas del sistema (insumos primarios y secundarios), los usuarios de los productos constituyen los componentes, y los productos representan flujos intermedios y las salidas del sistema. El sistema se puede construir para toda la región o caracterizarse por subregiones y municipios.

- **La oferta (o producción) forestal** se dividió en dos grandes rubros: pino (incluye pino y oyamel) y encino (incluye encinos y otras latifoliadas). En el caso del pino se incluye la categoría especial de aserrín y madera con corteza, mismos que constituyen desperdicios de la industria de aserrío, pero entran como insumos (combustible) de industrias regionales como tabiqueras y talleres alfareros. Para cada género se distingue, además, por lo menos cualitativamente, la parte correspondiente a troncos, ramas y madera muerta.
- **Usuarios de productos forestales** incluye dos tipos principales de agentes: los usuarios o empresas procesadoras de madera (aserraderos, molinos de astilla, sierra cintas, carpinterías, resineras, hacheros, tejamanileros, carboneros y leñadores) y las empresas o usuarios que usan madera como combustible (panaderías, industria artesanal del cobre, tabiqueras, alfarerías y usuarios domésticos: consumidores de leña para uso residencial).
- **Los productos.** Hay una gran gama de productos de la actividad forestal —o que tienen como insumo energético un producto forestal. Éstos también pueden clasificarse en productos primarios (como carbón, leña para venta, resina, astillas, tablas y polines, cuarterones y cajas de empaque o tejamanil) y productos secundarios, ya sea de madera (tablas, muebles, papel, juguetes, bateas…) o que requieren de leña como insumo (cerámica, tabiques, pan, cobre y otros).
- **Las interrelaciones de los usuarios**. Los productos de una actividad (por ejemplo, leña o madera aserrada) pueden ser insumos de otra (alfarería o carpintería, respectivamente), y las interacciones pueden ser bastante complejas. Asimismo, diferentes empresas pueden competir por el mismo recurso. En detalle más fino pueden caracterizarse interrelaciones de tipo geográfico, es decir, industrias que dependan de insumos primarios o secundarios provenientes de otras localidades de la misma región.

2 Consumo de productos forestales

El consumo de productos forestales se calculó separadamente por género, tipo de empresa y comunidad, para un total de 61 comunidades de la región con presencia de empresas consumidoras de madera. Se divide en dos categorías: consumo total y consumo de madera en rollo.

- **Consumos totales de madera y leña.** El consumo total se estimó como el producto del número de empresas por tipo y la demanda específica (intensidad de consumo) de cada empresa. El número y la ubicación geográfica de las empresas consumidoras de madera y leña se obtuvieron a partir de una encuesta aplicada en 61 localidades de la región, entrevistas a personas clave, revisión bibliográfica y visitas de campo. Los consumos de madera se desagregaron por pequeña industria, especie o género de madera consumida y se calcularon por comunidad, municipio y subregión. Para obtener estos consumos se calculó una intensidad de consumo por establecimiento y se multiplicó por el número de establecimientos en el municipio. Las intensidades de consumo se obtuvieron de la literatura, mediante una revisión extensa de artículos y reportes específicos sobre las distintas empresas consumidoras de madera y leña. Para alfarerías, personal de GIRA realizó mediciones directas. Estas estimaciones representan entonces los valores promedio más precisos que pueden obtenerse en el ámbito regional.
- **Consumos de madera en rollo.** La madera consumida por las pequeñas empresas (PE) regionales es subproducto de las actividades de otras empresas. Por ejemplo, muchas de las tabiqueras se abastecen exclusivamente de desechos de la madera aserrada, mientras que una gran cantidad de carpinterías depende de los aserraderos. Para calcular el consumo de madera proveniente directamente del bosque —en el presente estudio la denominamos “madera en rollo”—, se deben excluir los consumos de los subproductos forestales. Esto puede hacerse de manera simple utilizando un factor f_{ijg} que varía entre 0 y 1 y toma en cuenta la proporción de la madera consumida por establecimiento, municipio y género que proviene directamente del bosque.

3 Oferta de madera y leña

La oferta forestal se entiende en este estudio como la producción natural del bosque según sus diferentes géneros. Se estimó como $O_g = E_g * ICA_g$ donde O_g es la oferta forestal, E_g son las existencias reales regionales por género en metros cúbicos e ICA_g es el incremento medio anual por género en m³/ha/año. Este incremento se basa en el volumen total árbol, incluida biomasa comercial y no comercial. Con base en diferentes estudios dasonómicos para comunidades de la región (Permisionarios de la Meseta Tarasca, 1995a, 1995b; García *et al.*, 1991), se supuso un ICA promedio de 3% para pino y oyamel y de 2% para encinos y otras latifoliadas y se aplicó un factor de expansión de 2 para incluir la biomasa no comercial. Se hicieron dos cálculos contrastantes sobre la oferta forestal regional: a) utilizando los datos disponibles sobre existencias forestales a partir de estudios para aprovechamientos comerciales en los principales municipios de la región, y b) suponiendo existencias promedio de pino de 80 m³/ha y una superficie forestal estimada para la región en 1993 (Bocco *et al.*, 1997). El primer procedimiento subestima la oferta, pues los datos de existencias no cubren generalmente las áreas sin potencial comercial. En el segundo caso, la oferta está sobreestimada, pues de 1993 a la fecha la desforestación en la región no se ha detenido. El valor real está seguramente entre ambas estimaciones.

4 Balance regional de la madera

La estimación del consumo regional de madera en rollo por género se conjuntó con la información disponible sobre existencias y crecimiento forestales en la región a fin de obtener una primera estimación del balance regional (oferta-demanda) de madera. Dada la gran incertidumbre, tanto en los datos de demanda como en los de oferta forestal, debe destacarse que las cifras obtenidas se presentan sólo con fines ilustrativos, y se dirigen exclusivamente a obtener una primera idea general de la posible magnitud de los déficit que genera la demanda actual de madera sobre los recursos forestales regionales. Matemáticamente, el balance de madera regional por género (B_g) puede expresarse como: $B_g = O_g - C_{rg}$ donde O_g es la oferta forestal y C_{rg} el consumo de madera en rollo por género, expresados ambos en m³/ha/año.

5 Impacto de los usuarios en la vegetación

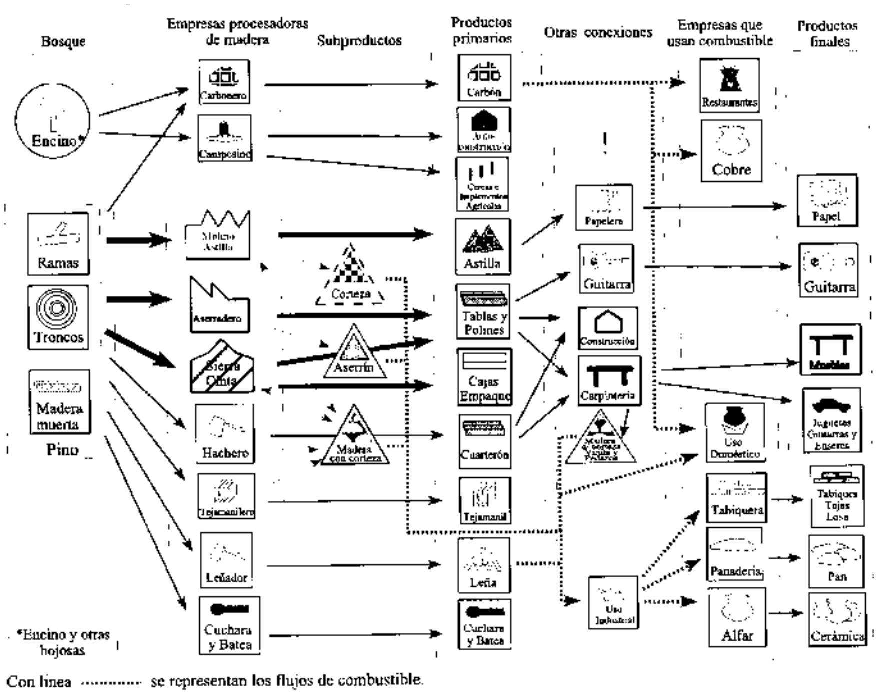
Determinar detalladamente el impacto de cada usuario en la vegetación es una tarea compleja. En este estudio se realizó un análisis general basado en tres criterios: a) el tipo de especies y parte del árbol utilizadas, b) el volumen de la demanda total por usuario y c) las condiciones de los recursos forestales locales. El análisis se realizó en los ámbitos regional y subregional, utilizando los datos de demanda y balance de madera (puntos 3 y 4 previos) y a nivel municipal mediante la construcción de un Sistema de Información Geográfica en IDRISI. Este último permitió obtener una tipología de municipios de acuerdo con el grado de deterioro y presencia de empresas y usuarios consumidores de madera.

Con la información obtenida en los cinco puntos anteriores se construyó una base de datos computarizada por comunidad que permite acceso rápido a datos ambientales. Se pueden realizar análisis de consumo y balance de madera por empresa, por género o por subregión. Adicionalmente se cuenta con información socioeconómica para los distintos usuarios de productos forestales (Masera *et al.*, 1997).

Resultados

Como se observa en la gráfica 1, la definición de sistema forestal convencional sólo comprende una pequeña fracción del sistema real de productos forestales en el ámbito regional. Específicamente, se deja fuera del análisis la mayor parte de las pequeñas industrias forestales y los usuarios domésticos del bosque. Asimismo, queda fuera la mayor parte del sistema ligado al aprovechamiento del encino y otras latifoliadas.

Considerado en su conjunto, el sistema forestal amplio es muy complejo, con múltiples conexiones entre empresas y productos forestales. Existe un total de 17 tipos principales de usuario que incluyen empresas y agentes de procesamiento primario de la madera, empresas que utilizan mayormente subproductos y finalmente empresas que recurren a la madera como combustible. El aprovechamiento del bosque da lugar a diez tipos de productos primarios, desde carbón y leña o madera de autoconstrucción hasta productos comerciales como astillas, cuarterones, tablas y polines, tejamaniles, cajas de empaque y resina. La subsecuente transformación de muchos de estos productos da origen a multitud de objetos que van desde papel hasta muebles, guitarras y juguetes. La leña y el carbón permiten la cocción doméstica y la elaboración de panes, tabiques y alfarería (gráfica 1).



Gráfica 1. Diagrama de flujo de biomasa

Demanda de productos forestales

La cuantificación detallada de la demanda de productos forestales se realizó exclusivamente sobre productos maderables y para combustible. Dentro de estos últimos se tuvieron que dejar de lado algunos actores primarios y sus productos derivados, como los hacheros, tejamanileros o el uso de madera para autoconstrucción, pues fue muy difícil cuantificar el número y los consumos asociados. El cuadro 2 muestra la lista final de empresas y sus consumos asociados.

En la nueva conceptualización del sistema forestal se identificaron aproximadamente 10,600 empresas consumidoras de madera en la región. De estas últimas destacan 3,900 talleres de alfarería (alfares), 500 talleres para la producción de juguetes y enseres domésticos de madera y 3,200 talleres de carpintería. La subregión Meseta concentra 60% de las empresas, la subregión Lago el 30% y la Cañada el 10% restante (cuadro 2). Además se estima que aproximadamente 220,000 personas cocinan con leña ya sea como combustible exclusivo o, en menor proporción, en combinación con gas LP. Un 90% de las empresas consumidoras de madera y la totalidad de los usuarios domésticos de leña no entran en las estadísticas oficiales porque pertenecen al sector informal o no están reguladas.

Las diferentes empresas presentan intensidades de consumo de madera y leña que contrastan en órdenes de magnitud (cuadro 2). Para las mismas empresas se dan variaciones importantes de las intensidades en el ámbito subregional. Las grandes empresas alcanzan intensidades de entre 3,000 m^3/año promedio en aserraderos hasta 15,000 a 23,000 m^3/año en astilladoras. Dentro de las pequeñas empresas, las más intensivas son la sierras cintas, con consumos por establecimiento que varían entre 350 y 1,100 m^3/año, seguidas por las carpinterías con un rango de 50 a 250 m^3/año, dependiendo del tamaño de la empresa (60 m^3/año en promedio) y finalmente los talleres de juguetes con 48 m^3/año. Entre las pequeñas empresas consumidoras de leña existe un rango de intensidades de 1.2 m^3/año para las unidades domésticas, alrededor de 7 m^3/año para los talleres alfareros y hasta 127 a 350 m^3/año para las tabiqueras, dependiendo de su tamaño (cuadro 2).

El consumo total de madera y leña en la región se estima en 1,557,000 m^3/año, de los cuales aproximadamente 1,300,000 m^3 corresponde a pequeñas empresas (cuadro 2). Un 66% del consumo total proviene de la subregión Meseta. La demanda total está dominada por las sierras cintas (33%), molinos de astilla (20%), demanda de leña para uso doméstico (17%) y carpinterías (11%), entre las más importantes. Se puede concluir entonces que más de la mitad (53%) de la demanda total de madera se dirige a usos como la astilla y la producción de cajas de empaque y tarimas, que representan productos con muy bajo valor agregado.

Existen diferencias significativas en el tipo y número de empresas por comunidad, municipio y subregión. En general ocurre una especialización por tipo de producto, empresa y comunidad, lo que resulta en un rico mosaico regional de actividades ligadas al uso de la madera y leña. El 90% de las sierras cintas, como la mayor parte de las astilladoras, se concentran en la subregión Meseta.

Unas doce comunidades (Santa Fe de la Laguna, Huáncito, Ichán, Tzintzuntzan, Patamban y Capula, entre las más importantes) concentran casi el 100% de la producción alfarera regional: la mayor parte de los pobladores se dedican a la producción de cerámica. Un caso similar ocurre con las carpinterías, donde destacan Capacuaro, Pichátaro, Corupo y Cuanajo, con más de 250 talleres por comunidad. La mayor parte de las comunidades se especializan en un determinado producto: sillas, madera torneada, muebles u otros tipos de enseres. La producción de juguetes de madera ocupa a 80% de los talleres en la ciudad de Quiroga. Las tabiqueras tienen dos fuertes zonas de concentración, la subregión de La Cañada y las afueras de la ciudad de Uruapan.

Cuadro 2 **Consumo de madera y leña en la Región Purépecha (m^3/año)**

	Aserradero	Sierras	Molino	Carpintería	Juguetes	Alfares	Tabiquera	Cobre	Guitarras	Bateas	Carbonero	Panadería	Leña doméstica	Total	Total PE
Meseta															
Núm. de empresas	8	853	11	2,133	98	1,080	117	0	846	240	61	120	134,003	139,570	5,567
Intensidad de consumo (m^3/empresa)	2,911	555	23,500	60	48	18	175	8	ND	ND	ND	25.6	1.2		
Consumo total (m^3/año)	23,289 2%	472,993 43%	258,500 24%	127,980 12%	4,704 0%	19,699 2%	20,475 2%	0 0%	0 0%	0 0%	0 0%	3,067 0%	163,037 15%	1,093,744 100%	930,707
Cañada															
Núm. de empresas	0	0	0	1	0	1,310	174	0	0	0	0	50	16,505	18,040	1,535
Intensidad de consumo (m^3/empresa)	2,911	555		60	48	18	350	8	ND	ND	ND	25.6	1.2		
Consumo total (m^3/año)	0 0%	0 0%	0 0%	60 0%	0 0%	23,894 22%	60,900 57%	0 0%	0 0%	0 0%	0 0%	1,278 1%	20,081 19%	106,213 100%	86,132
Lago															
Núm. de empresas	25	83	3	745	403	1,490	96	200	0	22	28	86	69,334	72,515	3,181
Intensidad de consumo (m^3/empresa)	2,911	555	16,580	60	48	14	175	8	ND	ND	ND	25.6	1.2		
Consumo total (m^3/año)	72,777 20%	46,024 13%	49,740 14%	44,700 12%	19,344 5%	20,490 6%	16,800 5%	1,593 0%	0 0%	0 0%	0 0%	2,198 1%	84,357 24%	358,023 100%	273,667
Total Región Purépecha															
Núm. de empresas	33	936	14	2,879	501	3,880	387	200	846	262	89	256	219,842	230,125	10,283
Intensidad de consumo (m^3/empresa)	2,911	555	22,383	60	48	17	284	8	ND	ND	ND	25.6	1.2		
Consumo total (m^3/año)	96,065 6%	519,017 33%	308,240 20%	172,740 11%	24,048 2%	64,084 4%	98,175 6%	1,593 0%	0 0%	0 0%	0 0%	6,543 0%	267,475 17%	1,557,981 100%	1,290,506

Nota: PE: pequeñas empresas; ND: no disponible. Los totales pueden no coincidir exactamente debido al redondeo.

Impactos en la vegetación

Los impactos de la actual demanda de productos forestales en la vegetación pueden estimarse por lo menos en términos generales: a) determinando las especies y parte del árbol que aprovechan los distintos usuarios de productos forestales, b) cuantificando la demanda total de madera en rollo resultante de esta demanda, c) estimando la oferta forestal y d) obteniendo el balance municipal y regional de madera para los principales géneros consumidos.

Impactos específicos por empresa

Como se mencionó en la sección anterior, las empresas y usuarios presentan diferentes niveles de intensidad de consumo de madera, tipo de insumos y parte del arbolado explotado, por lo que presentan un impacto diferenciado en la vegetación local (cuadro 3). En general, la mayor parte del aprovechamiento de coníferas se concentra en el tronco de arbolado vivo, mientras que de los encinos se utilizan también ramas. Dentro de las especies citadas como las más importantes en la elaboración de los productos de las empresas forestales primarias se encuentran: *Pinus douglasiana, P. harwtwegii, P. leiophylla, P. michoacana, P. michoacana var. cornuta, P. montezumae, P. montezumae f. macrocarpa, P. oocarpa, P. pringlei, P. pseudostrobus, P. tenuifoia, P. teocote, Abies religiosa, Quercus laurina, Quercus rugosa, Quercus spp*. En la elaboración de muebles, guitarras y objetos decorativos se utiliza también *Arbutus spp, y Alnus, spp* y *Tilia spp*. Para leña las especies más comunes son *Quercus crassipes, Quercus rugosa, Quercus spp, Arbutus spp, Alnus, spp y Pinus spp.*

Cuadro 3 **Géneros y parte del árbol utilizados por tipo de industria en la Región Purépecha**

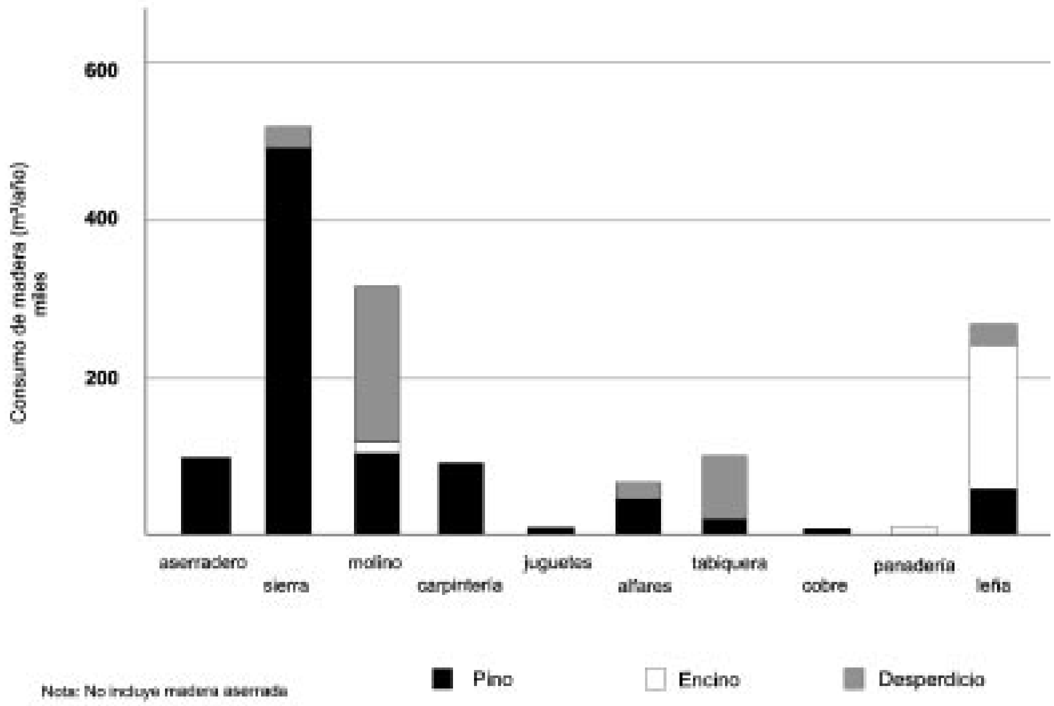
Tipo de industria	Principales géneros utilizados	Parte del árbol
Aserradero	*Pinus spp; Abies spp*	Tronco
Sierra cinta	*Pinus spp y Abies spp*	Tronco
Molino astilla	*Pinus spp Quercus spp*	Desperdicio
Carpintería	*Pinus spp, Alnus spp, Abies spp, Arbutus spp,* otros	Tronco
Alfares	*Pinus spp*	Tronco, ramas
Tabiquera	*Pinus spp, Quercus spp*	Tronco, ramas, aserrín
Cobre	*Pinus spp*	Tronco, ramas
Guitarras	*Pinus spp, Tilia spp,* otros	Tronco
Tejamanilera	*Pinus spp*	Tronco
Juguete	*Pinus spp, Arbutus spp*	Tronco
Panadería	*Quercus spp, Pinus spp*	Tronco, ramas, desecho
Cuchara y batea	*Pinus spp*	Tronco
Usuarios domésticos	*Quercus spp, Pinus spp, Alnus spp*	-Tronco y Ramas (*Quercus y Arbutus*), Ramas y desperdicio Aserradero (*Pinus spp*)

Cuadro 4 — **Demanda de madera por género (m^3/año)**

	Aserradero	Sierras	Molino	Carpintería	Juguetes	Alfares	Tabiquera	Cobre	Guitarras	Bateas	Carbonero	Hachero	Panadería	Leña doméstica	Total
Madera en rollo	96,065	492,068	110,436	86,442	1,920	39,268	18,375	797	0	0	0	0	5,235	240,727	1,091,336
Pino y oyamel	96,065	492,068	104,914	86,442	1,920	39,268	18,375	797	ND	ND		ND		53,495	893,344
	11%	55%	12%	10%	0%	4%	2%	0%	0%	0%	0%	0%		6%	100%
Encino			5,522								ND		5,235	187,232	197,989
			3%										3%	95%	100%
Madera aserrada				86,298	22,128										108,426
				80%	20%										100%
Pino				86,298	22,128										108,426
Desperdicio de industrias		26,949	197,804			24,816	79,800	797					1,309	26,747	358,222
de aserrío y PE.		8%	55%			7%	22%	0%					0%	7%	100%
Pino			197,804			24,816	79,800	797					1,309	26,747	331,273
Aguacate		26,949													26,949
Total	96,065	519,017	308,240	172,740	24,048	64,084	98,175	1,593					6,543	267,475	1,557,984
	6.2%	33.3%	19.8%	11.1%	1.5%	4.1%	6.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.4%	17.2%	100%

Balance de madera

La demanda directa de madera en rollo (es decir, solamente la madera que se extrae del bosque) alcanza 1,091,000 m³/año (cuadro 4). Aproximadamente 85% proviene de pino y 15% de encino (cuadro 4). Las pequeñas empresas tienen una demanda específica por especie y parte del árbol (gráfica 2). De la demanda directa de madera de pino, 55% se destina a sierra cintas y 14.3% a las PE constituidas por carpinterías, alfarerías y juguetes. Por otro lado, de la demanda directa de encino, 95% se dirige a los usuarios domésticos.



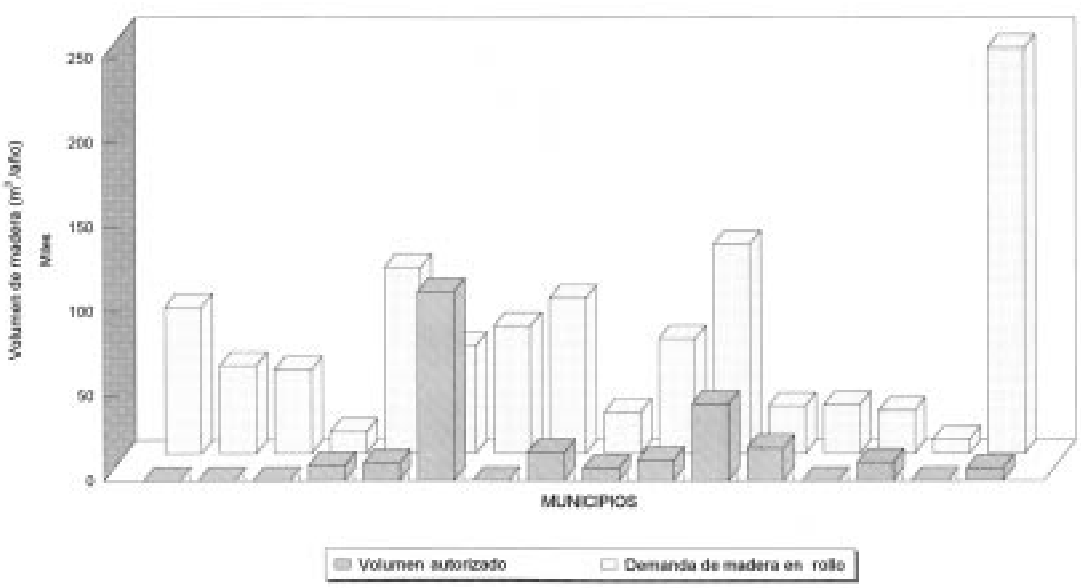
Gráfica 2. Consumo de madera por especie en la Región Purépecha

La oferta regional de madera está muy por debajo de los consumos estimados; su déficit neto alcanza entre 605,000 y 815,000 m³ por año con respecto al incremento medio anual de los bosques de la región (cuadro 5). La demanda de madera en rollo en las empresas seleccionadas supera en más de siete veces los volúmenes de madera autorizados para la región según datos obtenidos directamente a través de la Semarnap, o en más de 4.5 veces estos mismos volúmenes según indica el Anuario Estadístico de Michoacán (INEGI, 1996). En efecto, mientras que la demanda anual estimada es de 1,100,000 m³/año, los volúmenes promedio autorizados en el periodo 1994-1996 alcanzan entre 150,000 y 250,000 m³/año.

Cuadro 5	Balance de recursos forestales (m³/año)				
	Oferta 1	Oferta 2	Demanda	Balance 1	Balance 2
Pino y oyamel (m³/año)	239,381		893,344	(653,963)	
Existencias (m³)	7,979,372				
Crecimiento (m³/año)	239,381				
Encino (m³/año)	37,881		197,989	(160,108)	
Existencias (m³)	1,894,059				
Crecimiento (m³/año)	37,881				
Total (m³/año)	277,262	450,963	1,091,333	(814,071)	(640,370)
Existencias (m³)	9,873,431	18,038,536			
Crecimiento (m³/año)	277,262	450,963			

Notas: Oferta 1: existencias con base en información para los municipios más importantes. A partir de estudios regionales (Permisionarios Forestales de la Meseta Tarasca, AC, 1995a y 1995b) y García *et al*. (1991), se estima un crecimiento promedio de 3% para pino y oyamel y de 2% para encinos y otras latifoliadas. Se aplica un factor de expansión de biomasa de 2 para obtener los volúmenes no comerciales de madera. Oferta 2: considerando la superficie forestal estimada en 1993, existencias promedio de 80 m³.

Como consecuencia de la sobreexplotación de los recursos forestales regionales, sólo un municipio (San Juan Nuevo) conserva el bosque en buenas condiciones. La mayoría de los municipios restantes han agotado sus recursos forestales o los tienen sumamente degradados. La gravedad de la situación queda manifiesta en la asimetría entre la demanda real de madera en rollo y los volúmenes de corta autorizados por municipio para la gran mayoría de los municipios de la región (gráfica 3).



Gráfica 3. Demanda real de madera en rollo versus volúmenes autorizados por municipio de la Región Purépecha

Discusión y conclusiones

Hacer un diagnóstico adecuado de las diferentes demandas que se ejercen sobre los recursos forestales locales es un primer paso indispensable para diseñar políticas efectivas de conservación de estos recursos. En este sentido, es fundamental incorporar al análisis todo el conjunto de usuarios, desde las grandes empresas forestales hasta la multitud de pequeñas empresas artesanales y los usuarios domésticos. Se debe atender asimismo tanto los géneros de carácter comercial industrial como aquellos otros que se destinan a usos considerados "no comerciales".

En el caso específico de la región purépecha, el análisis amplio del sistema forestal nos permite concluir:

- **El "sistema forestal regional" en su conjunto se conoce poco y está completamente rebasado por la demanda regional de madera y leña.** Específicamente, la demanda de madera en rollo excede entre 4.5 y 7 veces los volúmenes de corta autorizados para la región. Se carece de estadísticas oficiales básicas, como número de empresas establecidas, capacidad de operación, tipo de insumos y productos, interrelaciones microgeográficas. La ausencia de información es particularmente dramática para las 9,000 pequeñas empresas consumidoras de madera y leña. Las estadísticas existentes cubren sólo las grandes empresas, con lo que dejan de lado más del 90% del total de establecimientos. De los 16 municipios que comprende nuestro estudio sólo uno, San Juan Nuevo, presenta un recurso forestal en condiciones adecuadas. En el resto, con muy contadas excepciones en el ámbito comunal, se ha verificado un proceso acelerado de degradación y deforestación con consecuencias muy negativas para la ecología y el futuro económico de la región.
- **La estructura actual de la demanda de productos forestales es poco compatible con las necesidades de empleo y desarrollo económico de la región, con lo que favorece el clandestinaje y la migración.** El 59% de la demanda total de madera y 63% de la demanda de madera en rollo se concentran en alrededor de 1,000 industrias intensivas en uso de madera (sierra cintas, astilladoras y aserraderos), que brindan poco valor agregado a la producción y que generan poco empleo por unidad de materia prima procesada. La venta de madera en rollo a otras regiones y la producción de tarimas y cajas de empaque con madera de pino representan por ejemplo usos altamente ineficientes de los bosques locales y una transferencia neta del "capital natural" a otras regiones.En contraste, el 47% restante de la demanda de productos forestales se reparte en más de 9,000 pequeñas empresas, que requieren *entre 10 y hasta 100 veces menos materia prima por empleo generado*. Además de su aporte a la generación de empleos, las PE artesanales contribuyen al fortalecimiento de la cultura local.
- **Las PE consumidoras de leña y madera representan en la región un sector diverso y complejo, pero clave en cuanto a su derrama económica y su impacto social. Destacan particularmente las carpinterías y talleres alfareros.** Noventa y ocho por ciento de las empresas consumidoras de madera y leña de la región se pueden calificar como "pequeñas empresas", conjuntando un total de 10,100 establecimientos o alrededor de 9,200 si se excluye a las sierras cintas. El 29% de las PE corresponde a carpinterías y 38% a talleres alfareros que generan 64% de los empleos totales. Las PE brindan empleo directo a más de 37,000 personas, beneficiando también directamente a alrededor de 150,000 personas, con lo que representan alternativas para frenar la migración. En varias comunidades rurales hasta el 90% de las familias depende de actividades ligadas con las PE. En las PE artesanales, los productos parten de la cultura y la identidad locales, y las refuerzan.

De este diagnóstico se puede derivar una serie de acciones prioritarias a corto plazo:

- **Regular las actividades ilegales de extracción y procesamiento de productos forestales que se conducen ilegalmente.** Esta regulación debería expresarse de manera diferente, según el tipo de empresas:
  1. En lo que respecta a empresas de alto consumo de madera y bajo valor agregado de la producción, como aserraderos, sierras cintas, astilladoras y algunas tabiqueras, deberían *aplicarse sanciones efectivas y hasta clausurarse* todos aquellos establecimientos que operen al margen de la ley. Asimismo, es urgente revisar el padrón actual de establecimientos, para asegurar que las empresas autorizadas dispongan realmente de las condiciones para operar en la legalidad (por ejemplo, observar si existe la posibilidad de abastecerlas de materia prima de origen legal).

2. Para empresas de mediana y baja intensidad de consumo de madera y alto valor agregado de la producción, como la mayor parte de las artesanales (carpinterías, talleres alfareros y de juguetes, artesanos del cobre, etcétera), se necesita una regulación que *estimule la competitividad y sustentabilidad del ramo a la vez que establezca límites al número de empresas por subregión*. Probablemente el primer paso indispensable es realizar un censo de establecimientos. Por la importancia de este tipo de PE en términos de empleo y derrama económica en las comunidades, más que orientarse a la clausura de establecimientos, la regulación debería fomentar que estas empresas hicieran un uso más eficiente de la materia prima y se abastecieran de madera legal.
3. Tener más control sobre la forma en que se ejercen los permisos de aprovechamiento y aumentar la vigilancia para evitar el clandestinaje en el monte. Un requisito indispensable para el éxito de este tipo de regulaciones es establecer una relación estrecha con las comunidades de la región, a fin de concientizarlas sobre la problemática del deterioro forestal y que sean estas mismas las que colaboren en la detección y control del clandestinaje.

- **Elaborar y desarrollar planes de manejo forestal que consideren la totalidad de las demandas que se ejercen sobre el recurso forestal.** Tradicionalmente, el manejo de los bosques se ha concentrado en la producción de madera en rollo de coníferas para abastecer las necesidades de las grandes industrias. Sin embargo, como ha demostrado este trabajo, las demandas sobre los bosques de la región son mucho más amplias y variadas. Es urgente entonces desarrollar planes silviculturales que hagan frente tanto a la necesidades de subsistencia de los pobladores (leña, postería, viviendas locales) como a los requerimientos específicos de las PE regionales. Cabría asimismo considerar algún tipo de incentivos económicos para aquellos predios en los que se realice un manejo forestal sustentable.
- **Promover enfoques de ecoproducción en las pequeñas empresas artesanales**. Este enfoque implica actuar de manera integral sobre la problemática ambiental regional promoviendo un modelo de producción que permita a los artesanos la generación de ingresos dignos y el rescate crítico de su cultura mediante el aprovechamiento sustentable del bosque (GIRA, 1994). Para hacer viable este modelo se debe actuar en por lo menos cuatro niveles:

1. Asegurar el abastecimiento sustentable de materia prima.
2. Eficientizar los procesos productivos (reducción del uso de materia prima) mediante la capacitación en tecnología y procesos de producción y la asignación de créditos preferenciales para la mejora de la infraestructura de los talleres.
3. Desarrollar nuevos y mejores productos mediante la capacitación de artesanos en diseño e innovación y un mayor control de calidad.
4. Mejorar los canales de comercialización, fortaleciendo el proceso de organización de los artesanos a fin de reducir el intermediarismo, identificar nuevos mercados o nichos de mercado y mejorar las utilidades de la producción. GIRA desarrolla actualmente este modelo en dos comunidades piloto de la región, la comunidad de Casas Blancas y de Santa Fe de la Laguna (Masera, 1997, y Navia, 1997), mismas que podrían servir de base para la posterior difusión regional del modelo.

- **Es necesario conocer con mayor precisión la dinámica regional de los recursos forestales y de las empresas consumidoras de madera.** Entre las acciones importantes en este ámbito están:

1. Realizar un censo detallado de las empresas consumidoras de madera y leña por comunidad y región de manera periódica.
2. Llevar a cabo estudios específicos sobre intensidades de consumo de madera y leña e impacto ambiental en las principales PE de la región.
3. Desarrollar un modelo regional del sistema forestal, que incorpore la demanda de productos comerciales y no comerciales, las grandes y pequeñas empresas y sus respectivas interconexiones.
4. Incorporar a las estadísticas forestales los consumos derivados de usos considerados “no comerciales” (como el consumo doméstico de leña) y de las pequeñas empresas del sector informal.

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Model forests and the International Model Forest Network

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I would first like to thank the organizers of the Morelia Conference for the opportunity to speak to you about model forests and the International Model Forest Network (IMFN). In my presentation I will be describing what model forests are, aspects of networking, the development of the IMFN and the work of the IMFN Secretariat.

The Model Forest concept

When one hears the term “model forests” visions of pristine forests and preserved areas may come to mind, and forests that are far from the intrusion of people.

Model forests are about the health and productivity of forests but it goes beyond the trees and the forests — **model forests are about people** (see Fig. 1). They are about how people use and interact with the forests and related resources, such as soil, water and wildlife. They are about communities that depend on the forests and the land base for their livelihood and well being. They are about forests in a defined area where the forests may be under multiple use for economic benefits both for traditional wood products and non-wood products. Model forests may include preserved areas such as parks or conservation areas and, as well, lands that are not forested and are being used for other production purposes, such as agriculture.

Model forests are also about community based partnerships and about learning to make decisions together. The partnerships are as broad-based as possible and include, among others, local industries, environmental groups, community associations, indigenous peoples, landowners, and governments. The partnership shares a common vision of sustainable development and of sustainable forest management.

A model forest is a process in which the partnerships collectively make decisions about the use of forests and the related resources on the landbase for all their values. Model forests are large-scale experiments covering a land base of significant size, such as a watershed area.

Model forests are also about networking. The model forest approach enables the groups that form the partnership to share their knowledge, understand better the sometimes conflicting practices used to manage the multiple forest values. They experiment and collectively find new approaches to meet their needs in the context of sustainable development, and to effect technology transfer. Networking occurs at all levels, including within the model forest itself, regionally and nationally within a given country, and globally.

Networking is an essential part of the model forest picture. The interaction between the Network and the individual model forests provides for sharing knowledge and experience and gives meaning, in the context of sustainable forest management, to the phrase “think globally, act locally”. The IMFN is the pipeline linking practitioners in model forests with each other internationally, with relevant international bodies, and with policy discussion at the global level. A recent example of networking was the IMFN Model Forest Forum that was hosted by the Chihuahua Model Forest in Mexico in October 1996. This was an opportunity for participants from 14 countries and NGOs to exchange experiences in partnership building and activities within their model forests and respective countries. Foresters as well as economists, researchers, farmers, company managers, students, ejidatarios, local community members represented the wide range of participants.

The Challenge

The model forest concept is a simple one, but complex in the practical terms relating to how partnerships are formed, how they learn to work together and how trust is developed. The players in the partnership are diverse, as are the expectation and demands placed on the forests and related resources within the model forest area. These demands and expectations are driven from social, environmental and economic viewpoints and they are often in conflict. The challenge is therefore to bring balance into these competing demands under the objective of sustainable forest management and to understand the consequences and trade-offs of actions and activities so that informed decisions can be made.

The International Model Forest Network is built upon the firm belief that forests can be managed in a sustainable way to enhance the economic, environmental and social well-being of current and future generations.

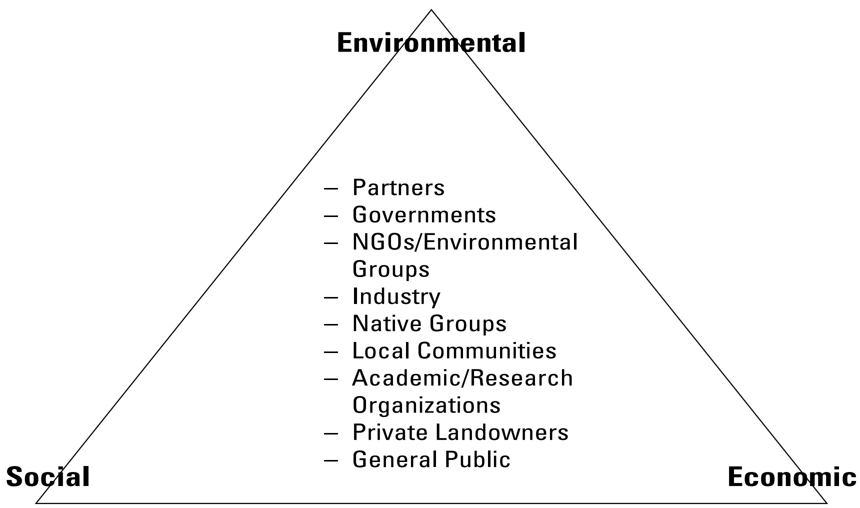

Figure 1. Stakeholders frequently involved in model forests.

No two model forests are the same

There is no standard template for model forests, as they are all unique. The attributes of partnership and sharing through networking are common to model forests; however, the activities and approaches taken to meeting the objectives of sustainable forest management must incorporate the variations and special circumstances found in the local environment due to differences in the social, cultural, economic and political setting. All model forests in the IMFN, however, cover the same range of activities:

- research
- education
- economic diversification
- networking

Model forests in Mexico provide an example of the diversity and range of activities. The process began in Mexico in 1993 with two model forests, the Chihuahua and Calakmul Model Forests. A third, the Monarch Butterfly Model Forest, was created in 1997. Each of these model forests is unique and is a story of how people can work together to recognize and enhance the economic, social, and environmental values of the forest. Each forest also covers a range of activities and the following examples highlight only a small portion of the activities currently under way in each model forest in Mexico:

- **Calakmul Model Forest, Campeche State, Mexico**

  Education efforts to raise the awareness of the local population about the wise management of forest resources is but one important activity in the Calakmul Model Forest. In the model forest area covering

380,000 hectares, education is important to the approximate 16,000 inhabitants, 50% of which are under the age of 15 years. Education efforts are directed to the young and to women, as these two groups were often marginalized in the region.

Environmental education programs constitute a means to integrate local populations in the efforts towards sustainable management of resources in this region; such programs will be key in inducing a shift in attitude and behaviour toward the use of the natural resource base. A wide range of tools are used and include:

- workshops and training courses (women's groups, school teachers, children, students etc.)
- community meetings to exchange information and experience on the use of forest plants and wild game as food sources,
- video presentations to attract attention and lead public discussion on key environmental issues such as the importance of forests in terms of the food chain, its ecology, fauna, flora, and importance to family's needs and values.

- **Chihuahua Model Forest, Chihuahua State, Mexico**

Knowledge about the state, extent and condition of the forests is essential to make informed decisions on the management of resources. Without such information decisions on the use or conservation of natural resources relative to economic, environmental and social objectives will occur in a vacuum and without knowledge of the positive or negative results of such decisions. Hence, research work into the development of tools that provide base information such as resource inventories is important, if the partners are to make informed decisions which would enable them to develop and elect the best strategies for the development of the resources.

For the Chihuahua Model Forest, research work has gone into developing the Geographic Information System (GIS) which has been used in the mapping and quantification of forests in the model forest area, which covers 110, 100 hectares. This computerized tool will allow examination of different management and development scenarios in an integrated approach taking into account social, economic and environmental dimensions and impacts. The GIS program in Chihuahua is focusing on developing such a database with data sets on thematic maps on climatic data, infrastructure/roads, human settlements, tourism activities, soil and vegetation, forest productivity, wildlife and its habitat, as well as specific tree species distribution.

- **Monarch Butterfly Model Forest, Mexico and Michoacán States (MBMF), Mexico**

Model forests have an important role in addressing local needs such as food security and the provision of benefits from economic diversification. Traditionally the forest has been managed mostly for its timber, or cut to clear land for agricultural and farming purposes. Economic diversification addresses the potential benefits that can be derived from sources other than the traditional use of forests for timber or conversion to agricultural land.

The MBMF has embarked on an economic diversification program so as to reduce the pressure its 900,000 inhabitants exercise on the forest resources. This program is designed to provide alternative income-generating options to the local communities, such as through tourism.

From October to March every year, millions of monarch butterflies find refuge in the forests in the mountains of the eastern part of the state of Michoacán and the western part of the state of Mexico. As a result of this spectacular migration, and other attractions in the region, tourism has become of increasing importance in recent years for many of the 22 municipalities within the 795,000 hectares in this model forest. The objective in this activity is to organize communities, other organizations and institutions to improve the facilities for tourism and overall management so as to procure additional income to local communities while preserving the forest habitat of the monarch butterfly.

Why an international model forest network secretariat?

The IMFN Secretariat was established in International Development Research Centre (IDRC) in 1995 with the support of IDRC and its Canadian partners: the Canadian International Development Agency, the Department of Foreign Affairs and International Trade, and the Canadian Forest Service of Natural Resources Canada. Its mandate is to work with those countries that are active in the IMFN (Canada, Chile, Japan, Malaysia, Mexico, Russia, United States) and assist those countries interested in experimenting with model forests and in joining the network.

The IMFNS Secretariat, therefore, in addition to assisting countries to develop model forests, has had an important role in encouraging and coordinating networking internationally. The Secretariat serves as a channel for planning and organizing annual forums, workshops, seminars, consultations and discussions.

Progress to date

The progress over the last three years has been significant and is demonstrated by the addition of a third model forest in Mexico, an 11th model forest in Canada, one in Chile and two in Japan. Other countries well advanced or currently exploring options to joining the Network include: Argentina, Australia, China, Indonesia, Poland, United Kingdom, Vietnam, and countries within the Southern African Development Community, such as Malawi and South Africa.

The way ahead

In late 1997, the Canadian partners supporting the IMFN assessed that their experience with the IMFN had been very positive in Canada and internationally. It indicated to members of the IMFN, and other countries that were developing their interests in model forests, it would continue its support for the IMFN and its Secretariat to March 2000. It stated, however, that Canada was at the stage where it was seeking partners to collectively chart the future of the IMFN and define a process to truly internationalize the IMFN. In an informal meeting of heads of forestry agencies held during the World Forestry Congress in Antalya, Turkey, agreement was reached amongst 12 countries on a process whereby they would work together to define country interests and expectations and discuss options on the possible ways and means of internationalizing the IMFN. This process is now underway and the challenge will be to determine networking needs at national and international levels, define organizational structures, governance and coordination for the IMFN and define obligations in support of the IMFN.

Recursos naturales y sistemas de información geográfica en comunidades indígenas del centro de México[1]

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Introducción

En México, como en otros países de América Latina, las comunidades rurales indígenas cumplen un papel preponderante en el control y manejo de los recursos naturales. En muchos casos, debido a problemas estructurales de los aparatos productivos y de las sociedades nacionales, estas comunidades se encuentran en situaciones de diferentes grados de pobreza. Todo ello tiene repercusiones importantes en el ordenamiento de los territorios comunales, la evolución de la diversidad biológica y cultural, y puede explicar parte de la causalidad de algunos cuadros de degradación ambiental.

El trabajo académico en comunidades indígenas, especialmente en esquemas de investigación participativa, puede cumplir un papel relevante porque influye de manera determinante en la relación sociedad-naturaleza. En estas circunstancias es posible combinar el conocimiento tradicional y el convencional, aprovechando asimismo los instrumentos automatizados de creación, manejo y análisis de datos geográficos y ambientales, orientados al manejo y conservación de los recursos.

Este tipo de investigación permite, entre otras actividades, la realización de inventarios precisos y actualizados de recursos naturales, el modelamiento de situaciones hipotéticas con manejo en diferentes plazos, y la evaluación de la aptitud de los suelos y de los riesgos de degradación y catástrofes naturales.

En este trabajo se describe y analiza un enfoque para la creación y gestión de datos ambientales en comunidades indígenas. El énfasis está en aquellos aspectos conceptuales de los sistemas de información geográfica y sus datos, que deben manejarse de manera particular en estos casos. Se analiza la experiencia en la comunidad indígena forestal de Nuevo San Juan Parangaricutiro, Michoacán, y se establecen algunas analogías con el caso de la zona de la monarca.

El marco conceptual

Los sistemas de información geográfica (SIG) son instrumentos (automatizados) de análisis espacial que permiten pasar de datos a información válida para la toma de decisiones. Los SIG favorecen la relación entre

[1] Este documento se basa en un manuscrito elaborado para el VIII Congreso Regional de SELPER (Mérida, Venezuela, noviembre 1997).

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ciencia y política en temas donde lo espacial es relevante (recursos naturales, biodiversidad, ordenamiento territorial, etcétera). El paso de datos a información supone el uso de modelos conceptuales originados en las disciplinas de aplicación específicas (ecología, geografía, economía…). Abordar el manejo de recursos naturales desde una perspectiva espacial requiere de la formulación de algún tipo de unidad espacial (por ejemplo, unidades homogéneas validadas estadísticamente).

En este contexto, concebimos los sistemas de tratamiento de documentos de percepción remota (PR), es decir, fotos, video, imágenes, como modalidades de los sistemas de información geográfica. Esto es válido independientemente de: 1) el formato de datos (analógico o digital); 2) el tipo de estrategia analítica (visual o automatizada). Para este estudio de caso, el objetivo principal de los sistemas de PR es el reconocimiento de patrones en la creación de unidades homogéneas, la extrapolación y validación de modelos.

Los aspectos operativos y técnicos deben estar subordinados a los aspectos conceptuales. Las herramientas técnicas deben: 1) ser versátiles y económicas en su configuración (hardware, software y capacitación); 2) ofrecer una adecuada relación costo-beneficio medida en términos de los resultados analíticos obtenidos, es decir el costo invertido para pasar de datos a información debe ser redituable, y 3) permitir la capacitación adecuada de los especialistas (campo-gabinete-cómputo)

Los riesgos comunes a evitarse son: 1) sistemas de análisis convertidos exclusivamente en almacén de datos o en sistemas de impresión (automatizada) de mapas, y 2) el sistema automatizado reemplaza al especialista en la toma de decisiones en cuanto a análisis y modelamiento.

Datos geográficos, tipos de datos y modelos de datos

Los datos geográficos describen objetos cuya distribución espacial es inherente a su naturaleza y como tal debe ser modelada (poblaciones, comunidades, ecosistemas, paisajes). Los datos geográficos se representan (y se escriben digitalmente) mediante entidades geométricas (puntos, líneas, áreas y superficies continuas). Lo geométrico responde a la pregunta acerca de la localización absoluta (georreferenciación). Lo geográfico responde a la pregunta de localización relativa (arreglos, patrones y relaciones espaciales entre objetos).

El dato geográfico describe objetos en tres dimensiones: 1) espacial (absoluta y relativa); 2) temporal (diacrónica y sincrónica), y 3) de atributos (variables espaciales). El concepto de unidades homogéneas (áreas cuya homogeneidad interna puede ser validada con métodos estadísticos robustos) permite manejar los datos geográficos en estas tres dimensiones en las bases de datos geográficos (BDG) de un SIG. Las BDG manejan modelos de datos convencionales: vectorial y en celdas (teselar o ráster) para lo espacial (puntos, líneas y áreas) y relacional (Sistemas de Manejo de Bases de Datos Relacionales) para los atributos.

El concepto de unidades homogéneas supone la factibilidad de segmentar objetos arreglados en el espacio (por ejemplo, elementos verticales y horizontales del paisaje). Estas unidades describen en el tiempo una organización jerárquica del ambiente cuyos elementos (abióticos, bióticos y de manejo) se distribuyen según gradientes potencialmente discretizables.

Las unidades homogéneas actúan como un modelo de la realidad (territorio donde se disponen los recursos naturales) que puede utilizarse con distintas escalas espaciales-temporales. El concepto de escala combina los conceptos de resolución, exactitud y precisión. El uso de enfoques multiescalares (anidados) y multitemporales (secuenciales) garantiza la posibilidad de moverse de lo general a lo particular, así como describir el dinamismo de aspectos ambientales (por ejemplo, el cambio en el uso del suelo).

El modelamiento espacial

El modelamiento espacial (Fotheringham y Rogerson, 1995) en un SIG se pone en práctica utilizando los siguientes grupos de técnicas analíticas: 1) clasificación (inventarios); 2) sobreposición aritmética y lógica (selección de sitios), y 3) vecindad y distancia (interpolación, modelos de terreno digitales, áreas de amortiguamiento o búfer, redes). El uso de estas técnicas supone un modelo del espacio, discreto o indiscreto, y la inclusión de la dimensión temporal (Langran, 1993).

En el tema que nos ocupa, los modelos más frecuentemente utilizados se inscriben en las siguientes problemáticas: 1) relación clima-hidrología (balance hídrico); 2) relación relieve-comunidades bióticas; 3) índices de diversidad biótica; 4) relación cobertura-uso del suelo; 5) aptitud de suelos y manejo de recursos; 6) relación oferta ambiental-demanda social, y 7) degradación y restauración ambiental.

Como puede apreciarse, abarcan diferentes aspectos relacionados con el vínculo sociedad-naturaleza, específicamente en lo tocante a la apropiación y manejo de los recursos naturales.

Es importante contar con un modelo espacial robusto, del tipo de las unidades homogéneas, o la interpolación de datos puntuales, o bien el del muestreo de la variabilidad espectral, o modelo de la percepción remota. En todos los casos, la cuestión de la resolución es fundamental y debe definirse cuanto antes en la investigación. Asimismo, debe considerarse la posibilidad de utilizar estructuras anidadas o jerárquicas (clases y subclases integradas).

Una vez resuelto ese problema, se debe optar por un modelo de datos, básicamente vectorial o ráster, pero esta opción no reemplaza a la anterior: responde más bien a características operativas o técnicas. De ninguna manera una estructura o modelo de datos reemplaza un modelo que conceptualiza al espacio que se analiza.

El caso de Nuevo San Juan Parangaricutiro

La meta del proyecto del cual se desprende este trabajo es generar y automatizar la información geográfica necesaria para desarrollar el plan de manejo de los recursos naturales de la Comunidad Indígena Forestal de Nuevo San Juan Parangaricutiro.

Los componentes del proyecto son: 1) investigación participativa en recursos naturales (comunidad indígena-universidad); 2) capacitación técnica (SIG, monitoreo de recursos); 3) educación ambiental. Los temas de investigación del proyecto son: 1) relieve, suelos, aptitud de suelos; 2) cobertura, vegetación, recurso forestal; 3) aprovechamiento y conservación de fauna silvestre, y 4) educación ambiental y ecoturismo.

La Comunidad Indígena Forestal de Nuevo San Juan Parangaricutiro se localiza en el estado de Michoacán, a unos 15 km al occidente de Uruapan, en la porción suroccidental de la meseta Purépecha. Su límite meridional está en contacto con la transición fisiográfica a la depresión del Balsas, con altitudes del orden de los 1,800 msnm. Las cotas mayores se encuentran en el centro y suroccidente, y son del orden de los 3,000 m (Cerro Prieto y faldas del Tancítaro, respectivamente). La porción suroccidental está constituida por las laderas de piedemonte del estrato volcán el Tancítaro, de casi 4,000 msnm, principal elevación del estado de Michoacán.

Se trata de casi 190 km^2 de terrenos volcánicos recientes y casi recientes, con cobertura original de bosques templados de pinos, abetos, encinos y sus asociaciones. Al menos un 50% de los terrenos se presentan cubiertos por espesores variables de cenizas del volcán Paricutín, localizado a pocos kilómetros de su lindero occidental. Las precipitaciones varían en el territorio comunal, pero se concentran entre mayo y octubre y su promedio anual es de alrededor de 1,500 mm. Las temperaturas medias anuales también varían, pero no superan los 15 ºC.

La comunidad, en su forma actual, es una consecuencia de la erupción del volcán Paricutín (1943-1952). Sus habitantes, originalmente localizados en la localidad de Paricutín, fueron desplazados por la erupción, y dotados de nuevas tierras, así como de una zona urbana en Nuevo San Juan, cabecera municipal.

En la actualidad, la comunidad se compone por 1,300 comuneros y sus familias. La población total de Nuevo San Juan es del orden de los 15,000 habitantes. La comunidad indígena desempeña un papel rector en las actividades económicas, sociales y culturales de la localidad de Nuevo San Juan.

Después de un proceso de cambio de uso del suelo (bosque a terrenos de cultivo de temporal en laderas volcánicas) para garantizar el abasto de alimentos, desde los años sesenta, la comunidad inicia el aprovechamiento sistemático de sus bosques de pinos (madera, resina y sus derivados) y garantiza la regeneración mediante un sistema de manejo por décadas de diversos sectores del bosque. Asimismo, se cuenta con un aserradero dotado con equipo de avanzada, sistemas de aprovechamiento de resina y fábrica de muebles y otros productos de la madera.

Todo esto le ha conferido a la comunidad un prestigio nacional e internacional y diversos reconocimientos públicos y de organizaciones no gubernamentales. La comunidad de Nuevo San Juan es un modelo de gestión comunal indígena de los recursos naturales. Una adecuada combinación de actividad empresarial y gestión comunal parece estar en el centro de este acertado manejo de los recursos.

La zona ha sido objeto de una gran cantidad de estudios relacionados con la erupción del Paricutín y sus consecuencias (entre otros, Segerstrom, 1950; Williams, 1950; Rees, 1970; Inbar *et al.*, 1993). Así mismo se han hecho estudios sobre la gestión de recursos y sus implicaciones sociales (Álvarez-Icaza, 1993).

Resultados

Los resultados obtenidos e integrados al SIG hasta el momento son:

1. Bases de datos a escala 1:50,000 y 1:25,000 de relieve (rocas, formas), suelos y cobertura, utilizando fotointerpretación, validación de campo y cartografía. A partir de esta base se formuló e instrumentó una leyenda integrada de paisaje mediante clasificación y sobreposición cartográfica. Las unidades cartográficas fueron conos monogenéticos, derrames lávicos, laderas de piedemonte, planicies y valles erosivos (véase Anexo)

   Estas unidades son las básicas para poder formular los esquemas de evaluación de tierras, conservación de la biodiversidad, ordenamiento y diversificación de las actividades productivas.
2. Bases de datos faunísticos, escala 1:25,000 que describen la diversidad por fragmento de unidad de paisaje.
3. Bases de datos para evaluar aptitud de suelos a escala 1:50,000 que describen la relación entre requerimientos de sistemas productivos agrosilvipastoriles y características de unidades integrales basadas en relieve-suelos.

En cuanto a capacitación, se desarrollaron cursos teórico-prácticos en los siguientes temas: 1) fotointerpretación, cartografía y sistemas de información geográfica; 2) levantamiento en campo de suelos y uso del suelo; 3) monitoreo de recursos bióticos y manejo de fauna, y 4) educación ambiental.

Las perspectivas que se abren para esta experiencia se orientan a avanzar en la integración conceptual, evaluación y validación del plan de manejo de los recursos naturales, así como a utilizar las bases de datos descritas para simular situaciones hipotéticas en torno a la diversificación productiva (agroforestería, ecoturismo, manejo de fauna, ganadería). Idealmente se buscaría extrapolar la experiencia a otras comunidades similares.

Implicaciones para zonas tipo monarca

La participación de las comunidades rurales en el manejo de sus recursos naturales permite apoyar la formulación de esquemas de ordenamiento sustentable del territorio. Para esto es clave la relación entre conocimiento campesino de los recursos, por un lado, y la utilización de tecnologías que permitan el manejo eficiente de datos. Por lo tanto, el apoyo en la adquisición de sistemas automatizados y en la capacitación para su uso puede ser una contribución importante de instituciones académicas hacia comunidades rurales.

El caso de Nuevo San Juan es particular, ya que pocas comunidades tienen una organización social tan consolidada. Éste sería el elemento primordial si se quiere desarrollar una estrategia similar en comunidades en la región monarca. En otras palabras, se puede tener sistemas avanzados, datos de buena calidad e incluso personal capacitado, pero si la organización social comunitaria no es robusta este tipo de experiencias difícilmente tendrá éxito.

Tal vez en la zona de las monarca se deba iniciar una estrategia que contemple experiencias piloto en las comunidades mejor organizadas. Si será una universidad o el propio gobierno el que impulse la aplicación, es algo que debe revisarse con atención.

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Anexo

1. Conos monogenéticos basálticos y andesíticos con cobertura de piroclastos, del Pleistoceno tardío y Holoceno, con andosoles o regosoles, y bosque templado.
   1.1 -Cineríticos, principalmente del Holoceno, con laderas rectilíneas.
   1.2 -Lávicos (tipo domos andesíticos de La Chimenea y El Tejamanil), del Pleistoceno, con laderas convexas.
2. Derrames lávicos del Pleistoceno, Holoceno y reciente.
   2.1 -Andesíticos del sur de la comunidad y mesas del norte, del Pleistoceno, con importante (≥1 m) cobertura de piroclastos alterados, con andosoles, y agricultura de temporal o pasturas, con erosión laminar e incipiente erosión concentrada.
      a. Superficies cumbrales, ligeramente convexas, pendientes ≤5%
      b. Laderas denudatorias, rectilíneas a convexas, pendientes entre 10 y 30%.
   2.2 -Andesítico-basálticos y basálticos (olivínicos), del centro y norte de la comunidad, del Pleistoceno tardío y reciente, con cobertura de piroclastos (≥.5 m), en algunos casos sepultados por la ceniza del Paricutín, con andosoles o regosoles, y bosque templado.
      a. Superficies cumbrales, rectilíneas, pendientes ≤5%.
      b. Laderas irregulares, en algunos casos caóticas, pendientes variables, ≥5%, hasta 30%.
   2.3 -Andesítico-basálticos del Paricutín, sin alteración evidente y sin cobertura de piroclastos, caóticos.
3. Laderas de piedemonte del Co. Tancítaro, con sustrato lávico andesítico Plio-Cuaternario y cobertura de material piroclástico retrabajado por procesos de laderas, pendientes rectilíneas ≤15%, con andosoles, con agricultura de temporal o pastizal.
4. Planicies acumulativas de nivel de base, con material piroclástico del Holoceno y reciente, con pendientes de ≤5% o planas.
   4.1 -Con material piroclástico retrabajado fluvialmente, con fluvisoles y agricultura de temporal.
   4.2 -Con cenizas del Paricutín, depositadas in situ (llano de Pario), con regosoles, sin cobertura vegetal o con reforestación controlada (en sustrato alterado).
5. Valles erosivos sobre materiales andesíticos pleistocénicos y volcánicos pre-pliocénicos de la formación zumpimito (lavas muy alteradas, lahares y otros flujos), controlados estructuralmente, con pendientes rectilíneas de > 30%, con andosoles y bosque mixto.

Análisis crítico del manejo de la Reserva Especial de la Biosfera Mariposa Monarca

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> "El área natural protegida está oficialmente declarada, pero no está siendo manejada en forma adecuada; por lo tanto, es una reserva virtual o reserva de papel" (Semarnap, 1996b; UICN y BID, 1993).

Desde que nuestro país fue sometido por los españoles, en el manejo de los recursos naturales no participaron los poseedores originarios (para nuestro caso, las culturas otomí, mazahua, matlazinca y purépecha). Después de aquel despojo, sus recursos, casi destruidos, les son devueltos en mínima parte a partir de la década de los años treinta, sin probabilidad alguna de manejo con acuerdo a su cultura y organización social. El manejo y conservación de los ecosistemas, por considerarlos de utilidad pública, reivindica el continuismo de la clase dominante conquistadora, en defensa del sistema económico impuesto, siempre buscando convencer al subalterno de que es cada vez menos capaz de pensar, hacer, querer o soñar por sí mismo, porque otros saben hacer, soñar, querer y pensar mejor que él.

Con la declaratoria de 1980, la Secretaría de Agricultura y Recursos Hidráulicos (SARH) impulsa en la región de la mariposa monarca del estado de Michoacán, en Sierra Chincua y Sierra del Campanario, un programa de vigilancia e instrumentación de mecanismos de control del turismo.

Con la creación y establecimiento de la Reserva Especial de la Biosfera Mariposa Monarca (REBMM), la SARH ejerce únicamente un manejo forestal de los recursos naturales (en las áreas de producción, sanidad, fomento y protección).

Mientras tanto, la Secretaría de Desarrollo Urbano y Ecología (Sedue), a través de su Delegación Federal en Michoacán, regulaba los aprovechamientos maderables; ubicaba las colonias de mariposa monarca, medía superficies, registraba el total de árboles ocupados por este insecto y desarrollaba el proyecto ecoturístico en el ejido El Rosario del municipio de Ocampo, con la participación de la agrupación Monarca, AC.

Para el estado de México, el manejo del área se concretaba a la vigilancia forestal. Para la presente década se incrementó la participación y número de instituciones oficiales del ramo que actúan en la reserva (SARH, Sedesol, INE, Profepa, Probosque, SDAF, Cepanaf, Semarnap, Sagar, Copromo), lo cual ha devenido en confusión y la ambigüedad de funciones y una marcada articulación de sus programas.

El esbozo del manejo de las áreas naturales protegidas se inicia con el Plan de Manejo 1993, elaborado por Monarca, AC, únicamente para el estado de Michoacán; este plan no fue aprobado por no estar sustentado presupuestal ni técnicamente (por deficiencias en la descripción) (Mcfarland, 1993). A partir de 1994, con los programas emergentes 94, 95, 96 y 97, se emprenden proyectos y acciones aisladas que se pueden enmarcar en estos componentes: manejo y protección de los recursos naturales; desarrollo social; administración; investigación científica, y educación ambiental.

Estos programas han sido un buen ensayo para lograr un primer acercamiento a los dueños de los recursos, pero han tenido deficiencia para atender una problemática tan compleja como la de la REBMM: a) techos financieros limitados y desfasados operativamente; b) falta de un programa de manejo que articule las distintas instancias; c) desvinculación de los programas oficiales y de organizaciones no gubernamentales; d) decisiones oficiales fuera de toda lógica operativa en la reserva; e) carencia de conocimientos sociales, culturales, económicos y ecológicos; f) falta de capacidad para resolver los conflictos ambientales generados por la inadecuada legislación, así como por la creación y establecimiento de la reserva misma; g) proyectos inadecuados culturalmente y elaborados sin consulta (oportuna) de los diferentes sectores que inciden en la reserva; h) dificultades que implica una reserva fragmentada y perteneciente a dos entidades federativas (México y Michoacán) y once municipios.

Para mayor ilustración, entraremos en detalle con la aplicación de la primera metodología del Listado de Evaluación de la CPNAP de la UICN. Esta metodología, que se estructura con 23 interrogantes, fue enriquecida con observaciones y valorada mediante la aplicación de rangos de calificación (que permiten una mayor objetividad) establecidos en una escala de cinco categorías: excelente, bueno, regular, malo, muy malo. Éstas son ubicadas en una escala ordinaria (4, 3, 2, 1, 0, respectivamente).

Evaluación de la efectividad en el manejo de la REBMM en1997

1. **Objetivos específicos claramente definidos para conducir la administración** (1)

   Esta área:

   Tiene los objetivos específicos para el área puestos por escrito.

   Observación:

   Con carácter muy restringido, éstos no aseguran la conservación del área, ni ofrecen expectativas para la solución de los conflictos, problemas y amenazas que se presentan en el área.

2. **Legislación** (1)

   Esta área no se encuentra adecuadamente protegida por la legislación nacional y carece de reglamentos locales

   Observación:

   La legislación vigente no resulta aplicable ante los conflictos ambientales generados por el uso tradicional de los recursos naturales, así como en la protección del ecosistema ante contingencias ambientales (plagas y enfermedades forestales e incendios).

3. **Información sobre recursos básicos** (1)

   Esta área cuenta con:

   Listados de flora y fauna; listado de especies con distintos estatus de conservación; cartas temáticas de geología, topografía y fotografías aéreas con escala 1:50,000; planos de la REBMM; pequeña biblioteca con publicaciones en materia ambiental, social, económica, legislación y de biología y conservación de la mariposa monarca.

   Observación:

   Se han centrado los esfuerzos en la especie carismática, descuidando la demás información del ecosistema y del geosistema.

4. **Información ecológica básica** (1)

   Esta área cuenta con:

   – Plan ecológico-forestal para la reserva de la mariposa monarca (un modelo de simulación para el manejo del oyamel).
   – Información básica de la especie carismática, dinámica poblacional, ciclo de vida, hábitat y relación depredador-presa.

   Observación:

   Es mucha la falta de información sobre sucesión ecológica, relaciones predador-presa, estado y tendencias poblacionales de especies indicadoras, dinámica de poblaciones de las especies de vida silvestre y demás información general que permita comprender las complejas relaciones de los organismos.

5. **Manejo de cuencas** (2)

   Esta área:

   – Protege microcuencas que, se considera, contribuyen al bienestar de las poblaciones humanas que habitan corriente abajo.
   – Es manipulada mediante obras de terraceo, canalización de arroyos, bordos, control de incendios y reforestación, que no están bajo la dirección, manejo y administración del área.

6. **Recursos genéticos** (2)

   Esta área:

   Del listado de especies de flora y fauna del área se tienen pocos datos disponibles, de manera que reciben poca atención especial.

   Observación:

   Aún no se cuenta con la información exacta de los factores que amenazan a las 15 especies de flora y 19 de fauna con estatus de amenazadas en la reserva.

7. **Plan de manejo** (1)

   Esta área:

   Tiene un plan de manejo en preparación que no ha incorporado a los diferentes sectores sociales locales en su fase de planeación.

   Observación:

   Se ha venido operando con Planes Anuales Emergentes desde 1994.

8. **Zonificación** (1)

   Esta área:

   Cuenta con una zonificación (zona núcleo y de amortiguamiento) que controla en parte el impacto humano y el desarrollo.

   Observación:

   Es necesaria una subzonificación para aplicar diferentes objetivos de manejo y reglas distintas a sitios particulares (áreas de invernación de la mariposa monarca) o zonas del área natural protegida.

9. **Límites** (1)

   El área posee límites descritos documentalmente, sin que los poseedores de los terrenos incluidos en el área los conozcan físicamente.

   Observación:

   El desconocimiento físico de los límites de la reserva ocasiona serios problemas a los diversos actores que inciden en ella, ya sea al querer aplicar programas de desarrollo social específicos o bien en la protección y en la conservación del área.

10. **Límites ecológicamente suficientes** (0)

    La reserva contiene únicamente un fragmento de un ecosistema natural, además de encontrarse fragmentada en cinco áreas naturales protegidas.

    Las áreas que pudieran servir de corredor biológico o de zona de transición están resultando alteradas y transformadas por las actividades antropocéntricas.

    Observación:

    Hay una marcada tendencia a la insularidad.

11. **Protección de los recursos naturales** (0)

Esta área:

- Sufre la extracción ilegal de la vegetación, pastoreo ilegal y cacería furtiva.
- Padece la explotación de ciertos recursos, como el suelo, rocas, flora y fauna.

Observación:

Ninguno de los programas oficiales ha tenido los resultados esperados debido a que no cuentan con el personal suficiente, están restringidos por una legislación que no corresponde a los conflictos ambientales y sobre todo no tienen el apoyo local de la gente.

12. **Investigación** (1)

Hasta el momento en esta área:

- No se cuenta con un programa de investigación en proceso o en proyecto.
- Se realizan investigaciones de tipo académico sin un control o coordinación correspondiente.

13. **Educación formal** (1)

Esta área:

Recibe a estudiantes en prácticas de campo informales, no supervisadas, durante la temporada de invernación de la mariposa monarca.

14. **Educación no formal** (1)

Esta área cuenta con los siguientes servicios para los visitantes:

- Folletos
- Senderos interpretativos
- Señalización (de ubicación, fijada en la zona de influencia del área)
- Servicio de guías (personal campesino capacitado sólo para los centros turísticos ejidales El Rosario, Chincua, Capulín).

15. **Turismo** (1)

- Se carece de un programa regional de turismo.
- El número de turistas rebasa la capacidad de regulación o control oficial o de los propios ejidos.
- La administración de los centros turísticos es realizada por las autoridades e integrantes de los ejidos El Rosario, Cerro Prieto y Capulín. Es evidente el impacto ambiental, por ejemplo, en erosión y pulverización de suelo.

Observación:

Los centros turísticos se pueden caracterizar con base en su desarrollo turístico de la manera siguiente:

- El Rosario: últimas etapas de auge, con una visita anual promedio de 100,000 turistas, congestionamiento en el sendero interpretativo, sin determinación de capacidad de carga. Centro de interpretación en completo abandono.
- Chincua: fase de despegue; visita mayor de 15,000 turistas, con proyección de crecimiento rápido; sin determinación de la capacidad de carga; sin un centro de interpretación ambiental, pero con instalaciones para trabajo de investigación, aunque carece de equipo.
- Cerro Pelón: fase incipiente; visita mayor o igual a 1,000 turistas; no cuenta con un centro de interpretación ambiental.

16. **Apoyo político** (1)

- Esta área es de alta relevancia política nacional e internacional. Sin embargo, la desarticulación de los programas en los diferentes sectores de la sociedad (nivel federal, estatal y municipal, de pobladores locales, ONG e instituciones académicas) no contribuye realmente a la conservación.
- La insuficiencia de apoyo (o franca oposición) de los habitantes locales constituye un serio problema.

17. **Participación local** (1)

    En el área:

    – Se involucra a los funcionarios del gobierno local.

    – Se involucra a los habitantes locales en fases tardías de la planificación.

    Observación:

    El establecimiento del área ha generado conflictos ambientales porque fue una decisión inconsulta, impuesta. Y aunque en el área la mayor parte de los propietarios muestra una franca oposición y desinterés, los demás sectores de la población local observan un gran entusiasmo por la conservación no sólo del área sino del ecosistema en su conjunto.

18. **Beneficios para la población local** (2)

    Cuenta el área con un recurso natural que podría ser un promotor de la actividad económica de la sociedad en su conjunto.

    Actualmente, las oportunidades de empleo son mínimas y los programas oficiales de desarrollo y de protección, escasos.

19. **Presupuesto** (2)

    La REBMM recibe un presupuesto insuficiente y tardío como para permitir que el programa emergente se instrumente adecuadamente.

20. **Mantenimiento** (1)

    Esta área cuenta con un presupuesto para mantenimiento, pero es insuficiente para conservar el equipo y las instalaciones en un estado razonablemente bueno, e incluso los caminos y carreteras se encuentran en mal estado.

21. **Personal y capacitación** (0)

    El personal es insuficiente y se encuentra apenas parcialmente capacitado en áreas naturales protegidas, con pocas oportunidades de asistencia a cursos o talleres para cubrir las necesidades del área.

    Observación:

    La profesionalización del personal técnico y de servicios no es fomentada e incluso la acumulación de experiencias resulta un inconveniente para los directivos impuestos "desde arriba" y "desde afuera".

22. **Equipo** (0)

    Se requiere de laboratorio equipado, equipo de oficina, equipo para labores de reconocimiento, material pedagógico, equipo de campo y para el manejo de flora y fauna.

23. **Apoyo externo** (2)

    El área:

    – Ha recibido y recibe apoyo externo.

    – Requiere de apoyo externo adicional (que ya se busca).

Evaluación de los ámbitos del manejo en la REBMM

En la aplicación de esta segunda metodología, elaborada por Henrique de Faria Helder, tenemos un 23% de efectividad en el manejo de la REBMM (véase el cuadro 1), esto es, un comportamiento insatisfactorio en los ámbitos administrativo, político, legal, de planificación, conocimientos, manejo, usos actuales, características biogeográficas y amenazas.

A partir del análisis conjunto de estas metodologías, podemos centrar nuestra atención en los siguientes puntos:

- **El aspecto legal**

  Declaratorias carentes de conocimiento bien sustentado, que restringen los derechos de propiedad, generan vacíos legales discontinuos que acrecientan los conflictos sociales y ambientales.

Consecuentemente, el marco legal debe revisarse en un esquema de participación social que derive en la aceptación de la figura jurídica y contribuya en forma decidida a la conservación y el desarrollo.

- **Aspecto sociocultural**

  Los dueños de los recursos que desarrollan su vida cotidiana en condiciones de marginación histórica de bienestar social y de servicios, así como económica, política y culturalmente.

  Es preciso, en la planificación, considerar más a los que se ha marginado con las limitaciones de dominio (impuestas con la zonificación de la reserva) y respetar sus decisiones respecto a un ordenamiento territorial; contribuir institucionalmente en la solución de la sustentabilidad de los recursos, y fomentar y estimular los sistemas rústicos tradicionales (ambientales y económicamente deseables) propios de su cultura y de su identidad.

  Puesto que los pobladores del lugar, en su conjunto, fueron, son y serán los resguardatarios históricos de los recursos naturales de la región, sin importar la figura jurídica que se les imponga, debe respetarse su derecho al manejo técnico y tradicional de sus recursos, libre de personajes ajenos a la región, a su vida cotidiana, cultura e idiosincrasia.

- **Aspecto ecológico**

  La REBMM se considera como una reserva de límites ecológicos insuficientes y una tendencia muy marcada hacia la insularidad.

  El problema de la fragmentación y la insularidad puede encontrar solución en el esquema de Bosque Modelo Mariposa Monarca, AC, siempre que se dé prioridad a los corredores biológicos para asegurar la protección de todas las colonias registradas fuera de la reserva, de los hábitats y del flujo génico necesario para la preservación de las especies.

- **Aspecto de investigación**

  Hasta el momento, las instituciones académicas, nacionales y extranjeras, han venido realizando diversas investigaciones sin la articulación y/o coordinación previas de la Dirección de la Reserva, que debería encauzarlas con acuerdo a sus líneas de acción prioritarias.

  Como prioridad para la conservación y el desarrollo social y productivo, es necesario impulsar la investigación aplicada que surja de la concertación con las instituciones académicas interesadas.

  De relevante importancia resulta estructurar el Sistema de Información Geográfica como herramienta de la investigación.

- **Aspecto institucional y de ONG**

  Ante la participación de más de diez instituciones de niveles federal y estatal es imprescindible la articulación de sus programas para lograr el objetivo de la sustentabilidad de los recursos.

  Las organizaciones no gubernamentales locales han permanecido casi siempre al margen de cualquier presupuesto y toma de decisiones, ya que las instituciones con mayor influencia monopolizan el destino de los recursos económicos, sin preocuparse de la capacitación e impulso de las pequeñas asociaciones locales que forman parte del patrimonio cultural de la región. En las ONG recae la responsabilidad de salvaguardar generacionalmente los recursos naturales.

- **Aspecto de la administración y el manejo**

  En general, la asignación de los recursos financieros, por tardía e insuficiente, ha afectado la eficiencia de la planeación y ejecución de las actividades de manejo.

  Por otra parte, el administrador y el grupo operativo rector, ajenos como son a la región, no se encuentran suficientemente familiarizados con el área como para percatarse de las líneas de acción prioritarias y resolver con tino y en tiempo los problemas más acuciantes.

  Lo siguiente puede servirnos de ejemplo:

  – Si aplicásemos indicadores de evaluación para el periodo 1 de enero a 15 de septiembre, tendríamos que el avance técnico se aproxima hasta 20% de las metas programáticas (a falta de un Consejo Técnico Asesor, de un Plan de Manejo Integral para la Ordenación Ecológica Territorial, de un Programa Regional de Ecoturismo y de los cuatro convenios de cooperación para la investigación, entre otros).

– Que de realizarse una comparación entre el gasto y el presupuesto, para el mismo periodo sería de un 28.5% de ejercicio.

Se repite la misma historia que en el ejercicio del presupuesto de las instituciones, un gasto dispendioso en un corto tiempo. Las acciones retrasadas por nueve meses, habrá que realizarlas al vapor de tres meses.

Es evidente que se deben aplicar las estimaciones independientes de expertos externos que, sin prejuicios, ordenen retomar o adecuar los métodos y estrategias aplicados (UICN y BID, 1993).

En toda la reserva, en resumen, existe un mínimo manejo del área protegida, lo que deja de lado acciones en aspectos esenciales e indispensables para cumplir con los objetivos.

Si a esto agregamos que la presente administración es ejercida por un grupo integrado completamente por personas ajenas a la región, a su vida cotidiana e idiosincrasia, sin la preparación y la experiencia en el manejo del área protegida, y con una tendencia muy marcada a desplazar de su plantilla operativa a los cuadros técnicos de la región, resulta que el pronóstico para la reserva es un manejo ineficiente con toda una serie de repercusiones indeseables sobre la biodiversidad, el desarrollo social y por supuesto sobre las poblaciones de la mariposa monarca.

Se requiere estructurar un directorio de investigadores que, en los ámbitos nacional e internacional, estén desarrollando estudios sobre la mariposa monarca y su medio.

Además de la indispensable participación de los pobladores, dueños y poseedores de la región de la mariposa monarca, en la administración y manejo de la reserva.

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Recursos naturales y su aprovechamiento en el área de la Reserva Especial de la Biosfera de la Mariposa Monarca

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Este texto parte de dos consideraciones básicas: la primera plantea que cualquier estudio y proyección para lograr un mejor aprovechamiento de los recursos naturales debe apoyarse en el análisis integral de las dimensiones ecológicas, sociales y culturales del área; la segunda plantea que es a través de las unidades familiares y su pertenencia a una comunidad social y cultural determinada como debe aprehenderse y entenderse el conjunto de recursos naturales, conocimientos y formas de aprovechamiento general que existen y pueden desarrollarse potencialmente.

Con estas consideraciones se propone un acercamiento al problema del aprovechamiento de los recursos naturales que resuelva dos de los problemas más comunes en los estudios sobre este tema:

1. El de concebir el medio ecológico como un sistema de recursos entendibles y potencialmente desarrollables en sí mismos, y que por tanto ignoran a las comunidades humanas que viven e influyen en ellos.
2. El enfocar los estudios a sólo un tipo de recurso natural y a sólo un tipo de aprovechamiento (recursos maderables, agricultura, ganadería, una mariposa, etcétera) que olvida que su dinámica y sus potencialidades de desarrollo están en estrecha relación y dependencia de los demás elementos del ecosistema, y que éste no puede concebirse sin tomar en cuenta las características sociales y culturales de las poblaciones que lo habitan y, de muchas maneras, lo han construido.

De ahí entonces que en este trabajo se parta primero de reconocer el medio ecológico presente, sus características y distribución geográfica, luego se establezca la distribución de la población humana que lo habita y después se analicen los sistemas generales de aprovechamiento que se han desarrollado en la zona a lo largo de miles de años de interacción entre hombres, culturas y medio ecológico. Sólo entonces se describen con mayor detalle las particularidades de las formas de uso de los recursos naturales.

Los ejes centrales de la explicación en cada una de las fases mencionadas son las comunidades y familias que trabajan, viven, conservan y transforman el medio ecológico, ya que son ellas con sus similitudes, sus diferencias y problemas las que han de guiar el establecimiento de las características de las posibles alternativas de aprovechamiento de ese medio. Sólo una perspectiva metodológica que ponga al hombre en el centro de los problemas de aprovechamiento y conservación de los recursos naturales, podrá tener posibilidades de viabilidad y éxito. Y sólo un estilo de conservación de la naturaleza que se preocupe por la sobrevivencia económica y el bienestar social y cultural de la sociedad que la habita tiene posibilidades de resolver la aparente contradicción entre la conservación y el desarrollo humano.

Los procedimientos que se siguieron para realizar este trabajo fueron la revisión bibliográfica, los recorridos de campo en siete comunidades, las entrevistas a especialistas, las entrevistas abiertas y dirigidas a la gente de la zona, las colectas etnobotánicas y la discusión con el grupo de trabajo.

Las subregiones

La región de la REBMM es bastante heterogénea en recursos naturales, origen y composición de su población y las problemáticas específicas de cada comunidad. Las diferencias obedecen a las condiciones ecológicas, socioeconómicas y culturales de las diferentes comunidades.

A grandes rasgos se pueden diferenciar tres subregiones:

a. La primera se sitúa alrededor del santuario Cerro Altamirano, ligada con las áreas de cultivo comercial de Maravatío y asociada a la problemática del río Lerma. La producción comercial de fresa y otros cultivos caracteriza esta subregión con una fuerte generación de empleos y la tendencia a concentrar alrededor de éstos a la población local que vende su fuerza de trabajo. La migración de algunos de sus habitantes hacia Estados Unidos es otra de sus características distintivas. Ecológicamente se trata de un área donde los bosques son primordialmente encinares y por tanto tienen un bajo valor comercial, aunque en las partes más altas existe también bosque mixto de pino-encino y de oyamel. El tipo de población es mayoritariamente mestiza, pero concentra población indígena en el municipio de Temascalcingo. La tenencia de la tierra es fundamentalmente ejidal y comunal.

b. La segunda subregión se localiza alrededor de los santuarios Chincua, El Campanario y Chivatí-Huacal. Se trata de una zona que floreció gracias a la actividad minera de la Colonia y el Porfiriato, y el cierre de la mina de Angangueo en 1993 ha traído fuertes desequilibrios económicos. La agricultura, que aquí se desarrolla en pendientes mayores del 15%, no cuenta con riego y se dedica al maíz para autoabasto.

   Los bosques predominantes son los de pino y oyamel y la explotación de estos recursos ha sido de gran importancia para su población. Aquí también existe una fuerte migración de población masculina y femenina, pero sobre todo hacia la Ciudad de México. Su población es mestiza.

c. La tercera subregión se encuentra ubicada en torno al santuario Cerro Pelón. Se caracteriza porque posee bosque mesófilo de montaña en las partes bajas, bosque de pino en las partes medias y en las partes altas bosque de oyamel. Hay una fuerte presencia indígena en los municipios de Zitácuaro y Donato Guerra. Algunas de las áreas agrícolas cuentan con riego y sus cultivos son fundamentalmente maíz, forrajes, chícharo y haba para el autoabasto. La migración de su población se dirige también hacia el Distrito Federal.

Distribución de la población y unidades familiares

A pesar de sus diferencias, estas tres subregiones comparten un patrón similar respecto del manejo de los recursos naturales. Por ello, en la descripción de los sistemas de aprovechamiento se les tratará de manera general, señalando las especificidades sólo cuando sean pertinentes.

Las similitudes en muchos de esos patrones de aprovechamiento permiten suponer que ha existido un fuerte intercambio tecnológico y de conocimiento entre las comunidades indígenas y las mestizas que dio como resultado el actual patrón general de manejo. Las comunidades indígenas han aportado germoplasma, conocimientos, técnicas agrícolas, formas de consumo y la perspectiva integral del aprovechamiento de los recursos naturales, en tanto que las mestizas han aportado algo de germoplasma, ganado, ciertos insumos e instrumentos agrícolas como el arado, y por supuesto también algunos patrones de consumo.

Los patrones de asentamiento de la población en estas subregiones guardan también algunas similitudes y diferencias. En los lugares donde predomina la población indígena el patrón es disperso, y la población se agrupa a partir del parentesco. Únicamente donde hay algo de población mestiza existen conglomerados de población que rebasan los núcleos familiares, como en el centro de la comunidad Crescencio Morales. Por su parte, en aquellos lugares donde predomina la población mestiza existen tanto patrones dispersos como los que aglutinan a las familias en poblados. En ambos tipos de asentamiento, las unidades de producción se corresponden con las unidades familiares.

En los dos casos, entre las familias campesinas predomina el aprovechamiento diversificado de los recursos naturales como estrategia para sobrevivir, organizadas en torno a la producción del maíz.

Los sistemas de aprovechamiento de los recursos naturales

Los sistemas de aprovechamiento que se han desarrollado en la región son el sistema agrícola, el solar, el bosque, la ganadería y la acuacultura. Actividades complementarias son la artesanía elaborada a partir de recursos locales, la venta de fuerza de trabajo y, para algunos pocos, el comercio y la extracción de arena y piedra. La delimitación y caracterización de tales sistemas de aprovechamiento se basa en el grado de perturbación o modificación del recurso, la intensidad de manejo y la organización y tipo de la fuerza de trabajo empleada.

Sistema agrícola

Este sistema se caracteriza por el grado de modificación permanente de los recursos donde se desarrolla una intensidad de manejo intermedia y se emplea la fuerza de trabajo familiar y social ("mano y vuelta" en las comunidades indígenas). Se compone de seis subsistemas: milpa, milpa en pendiente, milpa de riego inicial, milpa de riego, cultivos de riego (diferentes del maíz) y cultivos de inundación.

En todos los subsistemas de milpa se produce maíz, frijol y chilacayote como productos básicos, y quelites como subproducto importante.

a. Las milpas se localizan en todas las subregiones, aprovechan las condiciones más o menos planas de los terrenos y se desarrollan en condiciones de temporal.
b. Las milpas de pendiente se encuentran sobre todo en la subregión de Chivatí-Huacal y El Campanario y se establecen en pendientes mayores de 15% y a veces hasta del 100 por ciento.
c. Las milpas de riego inicial son las que cuentan con un solo riego para asegurar la germinación del maíz, adelantar el ciclo y permitir una cosecha temprana de elote. Se detectó en Chincua y Donaciano Ojeda.
d. La milpa de riego es el cultivo de maíz mediante sistema de irrigación, en el ciclo de invierno, principalmente para forraje. Se encuentra en las subregiones que cuentan con riego, sobre todo en las comunidades Donaciano Ojeda y Crescencio Morales, de la subregión Cerro Pelón. En las comunidades donde predomina el patrón de asentamiento disperso, las unidades familiares tienen dos espacios para milpa, uno de ellos siempre junto al solar de la casa habitación y el otro un poco más lejos en los pies de monte o en las laderas. Cuando poseen estos dos terrenos pueden alternar cultivos, a manera de año y vez. En ocasiones estas comunidades destinan a cultivos de riego el espacio cercano a la casa, o bien se da una rotación de maíz con otros cultivos de temporal, como avena forrajera. El aumento de la población ha dificultado mantener el sistema de año y vez y obligado a una intensificación del uso del suelo.
e. Los cultivos de riego se encuentran en Donaciano Ojeda y Crescencio Morales. Aprovechan el agua de los manantiales bajo formas de riego tradicionales y modernas. Por lo general están en las partes más bajas. Aquí se siembran productos tanto para el autoconsumo como para el mercado. Destacan el chícharo, haba, papa, trigo, tomate, cebada, entre otros.
f. Los cultivos de inundación aprovechan la humedad que queda en los terrenos una vez que bajan los niveles de las presas y ríos. Se siembran principalmente con avena. Fueron observados en la región de Chincua y se reportan en Altamirano.

Los rendimientos más bajos, unos 600 kg/ha, se encuentran en las milpas de ladera. Las milpas de las tierras planas presentan rendimientos hasta de dos toneladas por hectárea.

Algunos apuntes sobre la producción del maíz

La raza de maíz predominante es la criolla, conocida como "palomero toluqueño". En las partes más bajas hay algo de maíz cónico, pero también blanco, amarillo, negro, rojo y pinto. Según Segundo y Gutiérrez, el maíz recibe en las comunidades mazahuas el nombre de *tho/o/*. El maíz amarillo, el blanco y el pinto, de consistencia dura, pesada y rendidora, se conocen como *tho/o/ k*'o *dya niji*, es decir "maíz que no corre", debido a que su ciclo es más largo, de marzo a octubre. El maíz rojo o rosado y el negro son considerados por la población como variedades *na niji*, es decir rápidos o violentos, y su ciclo dura de junio a octubre. Se siembran en las tierras de temporal cuando las lluvias se retrasan. Tienen la ventaja de que germinan en cualquier tipo de suelo.

La mano de obra es predominantemente familiar. La toma de decisiones y los trabajos más pesados recaen en los adultos masculinos, pero las mujeres y los niños participan en todo el proceso. Muchas veces se contrata a peones locales. El pago puede ser en dinero o en maíz. La mano y vuelta sigue vigente en las comunidades indígenas, aunque no con el grado de importancia que alguna vez tuvo.

La utilización de fertilizantes químicos es general. El reciente incremento en los costos de este insumo hace más dramática la situación de los campesinos de la región, que además deben pagar cantidades elevadas por el transporte del fertilizante a sus comunidades. El uso de abonos orgánicos es común en las comunidades indígenas, sobre todo mediante la práctica del corral móvil. También se esparce la ceniza del fogón y la basura de la casa sobre los terrenos. En los cultivos de riego también es frecuente el empleo de insecticidas.

En los cinco subsistemas el tipo de mano de obra es familiar, con una participación relevante de la mano de obra masculina adulta en la toma de decisiones y en las tareas de preparación del terreno. La mano de obra femenina y de los niños se emplea para tareas como la siembra, la cosecha y la escarda. Cabe decir que a consecuencia de las migraciones masculinas adultas la participación de mujeres y niños es cada vez mayor en las tareas antes exclusivas de los hombres.

El principal punto de estrangulamiento en la producción de maíz es la compra del fertilizante químico. Si se considera que este cultivo no es económicamente redituable, los recursos para comprar el fertilizante tienen que salir de los otros sistemas: el bosque, la ganadería, la venta de fuerza de trabajo o una combinación de éstos. El fuerte incremento en los precios de los fertilizantes y la disminución de las fuentes de trabajo en la Ciudad de México seguramente traerán como consecuencia un incremento en el clandestinaje forestal como forma de obtener el dinero necesario para la compra del insumo.

Es urgente establecer programas de investigación regional orientados hacia el mejoramiento de las semillas criollas de maíz, la evaluación de los métodos de fertilización orgánica y rotación de cultivos y la conservación de suelos.

El solar

Este sistema se caracteriza por un grado de transformación permanente de los recursos naturales, donde se desarrolla un manejo más intensivo (se establece en áreas reducidas alrededor de la casa habitación) y el empleo de mano de obra familiar, principalmente de mujeres y niños. El solar se compone de tres subsistemas: frutales, hortalizas y plantas medicinales, condimenticias y de ornato.

Las áreas dedicadas a los frutales son generalmente reducidas, con pocas especies e individuos, principalmente manzanas, peras, aguacates, capulines, duraznos, ciruelas andrinas, nopales, tunas, granadas e higos destinados al consumo familiar. En algunas ocasiones se cuenta con riego para los frutales.

En algunas comunidades, como Crescencio Morales, se puede observar el establecimiento de algunas huertas de aguacate. Este subsistema, dada su importancia para el consumo familiar, requiere de un mejor conocimiento y se necesita explorar sus posibilidades de mejora.

El subsistema dedicado a la producción de hortalizas ocupa áreas muy pequeñas, de uno o dos metros cuadrados del solar familiar. Se producen algunas especies como acelgas y cilantro. Cuenta con riego a través de mangueras.

El subsistema dedicado a las plantas medicinales y de ornato ocupa también espacios del solar reducidos, mientras que algunas son sembradas en macetas. Son comunes la ruda, estafiate, romero, yerba maestra, sábila, bolita de hilo, bugambilia, malva y alcatraz, entre otras muchas. También cuentan con riego y se destinan para el consumo familiar.

La presencia de animales domésticos y el uso de la basura doméstica dentro del solar supone un proceso de mejoramiento de la calidad del suelo y, por ende, de mejores y más altos rendimientos en estos subsistemas. Por ello su mejoramiento requiere más atención.

Sistema de aprovechamiento del bosque

Se caracteriza por un grado de transformación mínima del medio ecológico en la medida en que emplea los ciclos naturales en el manejo de sus recursos, además de que recurre a elementos del propio medio, en contraposición a lo que sucede en los otros subsistemas en los cuales el manejo e intensificación depende de elementos externos (semillas, insumos, etcétera). El aprovechamiento del bosque se compone de cuatro subsistemas: aprovechamientos maderables, recolección, extracción y aprovechamiento de la fauna silvestre.

El subsistema de aprovechamiento maderable se basa en el manejo de especies maderables: pinos, oyamel, aile, etcétera. Emplea una forma de organización del trabajo y de toma de decisiones fundamentalmente colectiva. La recolección incluye las plantas medicinales, hongos, frutos silvestres y plantas de ornato y ceremoniales (sobre todo, musgo, heno y gallitos). La mano de obra es familiar. La recolección de hongos en las comunidades indígenas es labor de las mujeres (adultas y niñas); en las mestizas, de los niños. La extracción de leña tiene gran importancia para todas las familias y todos la realizan, pero fundamentalmente los niños. Otras extracciones son tierra de monte, principalmente para abastecer los viveros, y piedra y arena. El aprovechamiento de la fauna se da a través de la cacería que puede ser individual o colectiva. Se reporta la extinción de especies como el venado. La caza se limita actualmente a conejos, ardillas y otras especies menores. En las comunidades indígenas hubo un amplio consumo de insectos (huevos de hormiga, chapulines) y especies acuáticas (ranas, acociles, peces) que en la actualidad prácticamente ha desaparecido.

La ganadería

La ganadería de solar comparte el espacio físico del sistema de solar. Su composición es fundamentalmente de rebaños de ovinos (la mayor parte de las familias tiene entre ocho y 14 borregas), y también de gallinas, caballos, asnos y algunas veces bovinos.

La mano de obra es familiar, primordialmente la de niños, ancianos y la femenina adulta.

Los niños pastores de rebaños de ovinos pueden ser miembros de la propia familia. En algunas comunidades este trabajo, que solía ser de los hijos varones, ahora es de las niñas, para que sus hermanos puedan asistir a la escuela (Segundo y Gutiérrez, 1988); en otros casos la realizan los ancianos y los niños, alternándose en horarios para permitir la asistencia de los menores a la escuela; en El Lindero se reporta que contratar a un niño que no es miembro de la familia cuesta 700 pesos al año, por trabajar todos los días de nueve de la mañana a cuatro o cinco de la tarde (datos de 1995). En estos casos, los niños no asisten a la escuela. Los niños combinan el pastoreo con la recolección de hongos y plantas medicinales para autoconsumo o para venta.

El ganado es como una alcancía: se vende algún animal en caso de emergencia económica.

La ganadería está íntimamente ligada al sistema de la milpa, pues le aporta abono orgánico mediante el empleo del corral móvil. Por otro lado, este subsistema entra en contradicción con el de aprovechamiento del bosque, tanto por los incendios provocados para fomentar el renuevo como alimento del ganado, como por el pastoreo en áreas reforestadas o que se encuentran en estadios tempranos de regeneración natural del bosque.

La apicultura

La apicultura aprovecha las condiciones naturales que siguen a las perturbaciones del recurso (floración de la vegetación arvense y ruderal). Es un sistema que sólo pocas familias manejan, pero con potencial para intensificarlo. La mano de obra empleada es la masculina adulta.

La acuacultura

Las frecuentes afloraciones de agua han creado condiciones para el aprovechamiento de recursos acuícolas —ranas, acociles, peces— que se han incluido en la dieta tradicional. Se pesca en los ríos, bordes, charcos, lagunas y un poco en las presas. Las comunidades mazahuas desarrollaron diferentes artes de pesca: nazas, anzuelos, represas-trampa, redes y explosivos. Se pescaban carpas, pescado largo, pescado blanco, charales, ranas, ajolotes, acociles, moscos de agua, tortuguillas (Nolasco, 1967, y Segundo y Gutiérrez, 1988).

Cada uno de los sistemas descritos y la acuacultura, como sus subsistemas, tiene diferente peso en las comunidades e incluso entre las familias de cada comunidad. No todas las familias manejan todos los subsistemas, sino que hacen diferentes combinaciones de acuerdo con sus necesidades y posibilidades. Características comunes en todas son que el cultivo de maíz sigue siendo el hilo conductor de los ciclos anuales; que todas las demás actividades giran en torno suyo, subsidiando y posibilitando su cultivo, y que la venta de fuerza de trabajo y la forestería son las principales fuentes de ingreso monetario (en El Rosario y Cerro Prieto es ahora el turismo). También es característico el hecho de que las demás actividades son complementarias y representan diversas fuentes de autoabasto y de ingresos esporádicos (pequeñas cantidades de dinero o bien ahorros para emergencias como en el caso del ganado), así como productos para el trueque y tracción animal.

Utilización de los recursos naturales

Una vez entendidos los sistemas de aprovechamiento de los recursos naturales podremos analizar en forma específica y particular el manejo que se hace de las especies vegetales, animales y minerales en la región. Para ello presentaremos la información con base en las categorías de uso señaladas por Hernández Xolocotzi (1991) y hacemos referencia al sistema de aprovechamiento al que corresponden.

Cabe señalar que la información que aquí se presenta es resultado de un periodo de trabajo muy corto y en absoluto pretende ser exhaustivo. Parte de la información botánica se presenta con nombres comunes porque se obtuvo en fuentes bibliográficas que no incluyen nombres científicos o porque no es temporada de desarrollo de esas especies y no fue posible colectarlas. Lo aquí presentado es un panorama general que puede abrir líneas de investigación futuras.

Recursos para la alimentación

El conocimiento detallado de las formas en que se elaboran los alimentos con base en los productos locales puede dar pie, por tanto, a políticas de mejoramiento de la dieta familiar haciéndola más factible y con posibilidades reales de mejorar la salud y la calidad de vida de las poblaciones rurales. Nuevamente aquí se consignan algunos ejemplos que pueden servir de apoyo para abrir líneas de investigación pertinentes para el desarrollo de la región.

Maíz, frijol y chilacayota: los productos básicos

El maíz

El maíz es uno de los productos locales aprovechados en cada una de sus diferentes etapas de maduración para elaborar diferentes alimentos. Las milpas sembradas con riego inicial son dedicadas casi exclusivamente a la producción de elote (tierno). En las milpas de temporal la resiembra se realiza con maíces de ciclo corto para garantizar que haya elotes para las festividades del Día de Muertos.

En todas las milpas las primeras cosechas son de elote tierno. Cuando éste sazona, el maíz de destina a la elaboración de tortillas, atoles, tamales, gorditas, pinole, reventadas (palomitas) y bebidas como el *sendecho*.

Según Segundo y Gutiérrez (1988), los maíces blancos cubren las necesidades básicas de las familias indígenas que los cultivan. Son los más comúnmente empleados para la elaboración de las tortillas, memelas o gorditas, tamales y atoles. El maíz rosado es blando y liviano, lo que facilita su molienda, y es con este maíz exclusivamente con el que se elabora el *sendecho*, la bebida tradicional de los *teetho naatho* (mazahuas). El maíz rosado y el negro, ademas de ser empleados para las comidas como tortillas, tamales y atoles, se utilizan para hacer reventadas (palomitas) y pinole, alimentos secundarios pero también especiales para los rituales y fiestas de la comunidad. En algunas comunidades el maíz se mezcla con trigo o con cebada para hacer tortillas combinadas. La ventaja de combinarlo con trigo es que así se evita el endurecimiento de las tortillas.

Algunas variedades locales de tamales son: los que se hacen de maíz blanco, rojo y negro; los tamales de rana y epazote con venas de chile pasilla; los tamales de acociles; los tamales de atepocates; los tamales de espiga, que son de masa de harina de trigo revuelto con la espiga del maíz, y los tamales agrios, rellenos de habas cocidas y molidas, entre otros.

El pinole se consume solo o bien en forma de *mu*, un postre muy gustado que se prepara con chilacayote hervido, pinole y azúcar. Entre los atoles están: el agrio, que se hace de maíz azul y se toma con dos o tres cucharadas de chile pasilla, el de zarzamora, el de maíz y el de capulín.

Esta especificidad en la elaboración de los alimentos según los diferentes maíces criollos explica en gran medida la resistencia de los pobladores locales a aceptar maíces híbridos o semillas procedentes de otras regiones, además de la adaptación que presentan las semillas regionales a los cambios climáticos locales. Explica también parcialmente por qué persevera en siembra a pesar de que no es una actividad económicamente redituable.

Frijol

El frijol es un producto de importancia básica que se siembra junto con el maíz. Los bajos rendimientos sin embargo han provocado que cada vez se siembre en menores cantidades en esta región.

Se siembran variedades de *Phaseolus vulgaris* (por ejemplo, chamacuero en Crescencio Morales). En El Rosario se reportó siembra de *Phaseolus coccineus*, aunque no quedó claro si es cultivo tradicional o recién introducido. El tiempo no permitió registrar las variedades presentes. Sería importante hacer un estudio al respecto.

Chilacayota
La chilacayota (*Cucurbita* sp) es otro de los cultivos asociados al maíz y su importancia para la dieta familiar se percibe en el hecho de que se cultiva en todas partes y al parecer con buenos rendimientos. Se consume tierna, como la calabacita, pero también ya madura en *mu*. Por su alto valor nutritivo valdría la pena promover su mayor consumo; por ejemplo, mediante un intercambio de recetas con otras regiones étnicas.

Quelites, nopales y maguey
Los quelites (varias especies, entre las que destacan *Amaranthus* spp, *Chenopodium* sp, *Malva* sp) y los nopales (*Opuntia* spp) representan, para la mayoría de las comunidades rurales de México, una fuente importante (en algunos casos la más importante después del maíz y frijol) de minerales, vitaminas y proteínas vegetales. Quelite es el nombre genérico que se aplica a plantas que si bien no son silvestres, tampoco son cultivadas, sino que se encuentran en diferentes fases del proceso de domesticación (no se debe olvidar la importancia de Mesoamérica en la domesticación de especies vegetales). El maguey (*Agave* spp) proporciona alimento, medicina, cercos vivos, abono, y es un método eficaz para impedir la erosión.

La importancia de los quelites, los nopales y el maguey para mantener o mejorar la calidad de vida de los pobladores locales, por su alto valor nutricional y su fácil acceso, constituyen factores a ponderar en la planeación de políticas regionales. Desalentar su consumo implica deteriorar aún más la dieta campesina.

Hongos
Durante la temporada de lluvias, desde junio hasta septiembre, se realiza una vigorosa recolección de hongos en toda la región. En las comunidades mazahuas, la recolección de hongos corresponde a niñas y adultas, mientras que en las comunidades mestizas es un trabajo que los niños realizan mientras pastorean. Existe un intenso mercado de hongos local. Aniceto (1985) presenta una lista de hongos reconocidos por los pobladores de Crescencio Morales, entre los que incluye: 45 hongos comestibles, 13 venenosos, dos alucinógenos, dos que crecen sobre madera y siete no identificados; además proporciona el nombre mazahua y las características generales de cada uno. Habla también de algunas prácticas tradicionales de cuidado y conservación de los hongos en los bosques.

Plantas aromáticas
De gran importancia en la región es el consumo de las plantas aromáticas, entre ellas el tabaquillo (*Satureja macrostema*) que se bebe cotidianamente como té. Por su excelente sabor y propiedades digestivas es una especie cuyo mercado podría expandirse.

Combustibles
En las comunidades indígenas sólo unas pocas familias poseen estufa de gas. En las comunidades mestizas de la subregión El Campanario hay más estufas, pero no sustituyen el uso mayoritario de la leña. Aun en comunidades donde está más extendido el uso de las estufas de gas, como en Chincua, la leña sigue siendo fundamental para el cocimiento del nixtamal y las tortillas, así como para calentar la casa. Podríamos decir que entre 80 y 90% de las casas de la región utilizan leña en forma cotidiana. La fabricación de carbón parece ser importante únicamente en la subregión Altamirano donde prevalece la vegetación de encinos.

La leña que se extrae de los bosques es en gran parte madera seca, residual de las explotaciones forestales. La extracción de leña funciona como práctica de limpia que reduce el material combustible disminuyendo el riesgo de incendio en los bosques, y siempre que la presión no sea excesiva se puede mantener un equilibrio entre esta actividad y el recurso. Por su importancia, este rubro amerita una investigación de mayor profundidad.

Recursos para la salud

La vigencia de la medicina tradicional en la región la evidencian las plantas medicinales cultivadas en casi todos los solares, su comercio en los mercados locales y la presencia de parteras, hueseros, curanderos, brujos y demás especialistas. Sobre todo en las comunidades indígenas, los partos se atienden en las casas con apoyo de las parteras.

Relevante en este sentido es la existencia en la región de dos organizaciones de médicos tradicionales indígenas: una en Zirahuato y otra en San Felipe del Progreso. Ambas cuentan con su jardín botánico y son apoyadas por el Instituto Nacional Indigenista.

Plantas medicinales

Se recolectan a orillas de los caminos, en las milpas, en los bosques, o bien se cultivan en los solares. En El Rosario se emplea un gran número de plantas medicinales (más de 170), aunque parte de éstas se compra en los mercados. Para muchas familias de la región, la recolección y venta de plantas medicinales es una actividad complementaria. Se comercializa trompillo (*Ternstroemia pringlei*), árnica (*Heteroteca inuloides*) y lucena (*Salvia* sp).

Argueta (1994) recopila la información disponible sobre medicina tradicional en las comunidades indígenas.

Fibras y textiles

Fibras de origen vegetal

La cestería y confección de bolsas a base de varas, sauce, jara, palma e ixtle también es una actividad importante para muchas familias indígenas y mestizas (Segundo y Gutiérrez). Mención especial merece el zacatón, *Muhlenbergia macroura* (HBK) Hitch., uno de los pilares económicos de las haciendas de principios de siglo; su explotacion le confería a la zona gran importancia económica y, por ende, política y cultural. Podría explorarse la posibilidad de mercado internacional como productos verdes que compitan con las escobas y cepillos de plástico.

Fibras de origen animal

De los borregos se obtiene la lana para la elaboración de *quechquemetles*, fajas y cintas. En Boca de la Cañada se hacen gabanes, cobijas, sábanas, morrales, servilletas; en Macho de Agua, gabanes y rebozos. Esta actividad es muy importante en las comunidades mazahuas; casi todas las familias poseen un rebaño de borregos, al que trasquilan y venden el vellón, o lo cardan e hilan. Muchos de los hombres tejen en telar de pie, mientras que las mujeres usan el telar de cintura. En Crescencio Morales hay alrededor de 80 tejedores de telar de pie. Los textiles mazahuas gozan de prestigio nacional e internacional por su calidad y belleza. El diseñador japonés Minoru Kobayashi ha desarrollado una línea de ropa moderna con textiles mazahuas.

Plantas ornamentales y rituales

Las personas que recolectan orquídeas para la venta realizan esta actividad durante casi todo el año, ya que las seis diferentes especies comerciales florecen en épocas distintas. En 1995 se vendía cada orquídea en flor, con huacal y musgo, en tres pesos en los mercados locales.

Espejo *et al.* (1992) reportan las siguientes especies de orquídea en la zona núcleo de Sierra Chincua: *Corallorhiza* sp, *Govenia capitata* Lindl., *Malaxis aff. soulei* Wms., *Prescottia tubulosa* (Lindl) L.O.Wms., *Schiedeela eriophora* (Rob. & Greenm.) Balogh, *S. hyemalis* (Rich. & Gal.) Balogh, *Spiranthes* spp. Madrigal (1994) reporta también la presencia de *Habernaria* sp. Éste es un recurso que debiera estudiarse para determinar si está ocurriendo una sobreexplotación y si existen formas de producción y mercados que paguen mejor o si pudiera crearse un jardín botánico que añada interés turístico a la región.

Difícil sería calcular las cantidades de musgo, heno y gallitos (*Tillandsia* spp) que son extraídos de los bosques de la región, sobre todo durante el invierno, cuando se vende para los altares de la Virgen de Guadalupe (12 de diciembre) y los “nacimientos” con los que las casas mexicanas festejan la Navidad.

Materiales empleados en la construcción

Construcción de casas

Los materiales para la construcción de casas han cambiado a lo largo del tiempo. Camacho Pulido (1985) hizo un estudio muy interesante al respecto en el municipio de Acambay. La descripción que hace para el poblado de San José del Rincón (cerca de Ocampo) es similar en cuanto a especies utilizadas.

Para las casas de madera reporta el empleo de pino, oyamel, ocote, aile, encino, capulín, pino, roble, aguacatillo y chicanten. Los techos se hacían de zacatón; en las comunidades indígenas las casas podían ser también de adobe y teja elaboradas en las comunidades mismas. En la actualidad hay una tendencia hacia la construcción con mampostería. En El Capulín una de las consecuencias negativas de la veda es que las familias no pueden reparar sus casas de madera.

Fabricación de instrumentos de labranza

Dado el carácter campesino de la población y la prevalencia de la agricultura tradicional, la elaboración de los instrumentos de trabajo tiene gran importancia. Camacho Pulido encuentra que los agricultores locales poseen un conocimiento muy preciso de las cualidades de las maderas de las distintas especies y saben cuál es la mejor para cada instrumento. Sería interesante hacer estudios parecidos en otras condiciones ecológicas de la reserva.

Plantas forrajeras

La caña y las hojas secas del maíz se recogen y almacenan en un tejabán especial en los solares. El ganado se lleva a las milpas después de la cosecha. También se les dan los olotes. Se recolectan *Brassica* sp de los cultivos de ciclo de invierno para darlo de comer a las borregas. Parte de los cultivos, como avena forrajera, alfalfa, trigo, cebada y maíz de riego, es destinada al ganado. Es un tema que amerita estudios más detallados.

Plantas melíferas

La producción de miel en la región tiene cierta importancia y seguramente cierto potencial de desarrollo, aunque condicionado por la altitud y las temperaturas frías. La miel de esta zona tiene fama de ser de muy buena calidad, de color claro y una concentración de humedad de entre 14 y 16%. La cosecha principal es la de otoño.

Cercas vivas y control de erosión

Entre los usos que tiene el maguey en esta zona, igual que en el resto del Altiplano, destacan el de cerca viva y control de la erosión. La cerca viva señala linderos entre propiedades y evita que entren animales en las casas y milpas. El desuso en el que ha caído se nota al no realizarse la siembra de nuevas plantas después de que alguna muere o, como sucede en Crescencio Morales, cuando se sustituye con cercas de otro material, como chatarra metálica, por ejemplo. Al parecer, alrededor de los desmontes recientes para milpa —por ejemplo, en El Rosario y en Crescencio Morales— ya no se siembra maguey, lo que incrementa el peligro de la erosión en las milpas de ladera.

Plantas tintóreas

Dada la gran importancia del trabajo textil, sobre todo de lana, en las comunidades indígenas se desarrolló el conocimiento de las propiedades de plantas tintóreas, que se ha perdido con el uso de las anilinas químicas que se empezaron a usar en México alrededor de los años cuarenta. En las comunidades mazahuas eran importantes el huizache, que da un color azul-verde; el muictle, también azul-verde, y la flor ruidosa o *nda/ns'ijni* que da color amarillo. Nolasco (1965) reporta también el uso del añil (*Indigofera suffruticosa* Mill.) en la región.

Segundo y Gutiérrez afirman que había también producción de grana cochinilla, conocida como *na mbaja*. De algunos minerales de la región se obtenían colores negros, blancos y grises.

Otras extracciones

Tierra de encino

Del bosque se extrae tierra de encino o tierra de árbol para su venta en los mercados, y para su uso en los viveros forestales de la región. Es difícil cuantificar cuánta sale para los mercados locales, pero se ha calculado la cantidad aproximada que se emplea para los viveros locales. Hay ocho viveros entre Zapata, Asoleadero y Chivatí-Huacal, que se han establecido en los últimos años en la región y producen alrededor de 3,000,000 de plantas. En caso de que éstas utilicen solamente tierra de monte en los viveros, se extraerían 1,832 camionadas de tierra de monte al año.

En caso de que usen tierra de monte revuelta con tupuri y arena, en proporciones de 30:30:40, calculan que se requerirían 550 camiones de tierra de monte anuales. En cualquiera de las dos formas son cantidades muy altas que requieren alguna regulación.

Piedra y arena

En Crescencio Morales se extraen actualmente grandes cantidades de piedra y arena para construcción. Esta extracción la realizan los dueños de camiones de las manzanas La Dieta y Macho de Agua y provoca conflictos con las demás manzanas. Se dice que la extracción la realizan las personas que antes sacaron de manera ilegal la mayor cantidad de madera en la población. También en San Felipe hay bancos de grava y arena. Al extraer la piedra y arena se resta terreno al bosque y las áreas agrícolas. Es una actividad que no tiene regulación alguna.

Conclusiones y perspectivas

A pesar de que en la región existe una población indígena minoritaria, su influencia está presente en el uso y manejo de los recursos naturales. Ello consta en la diversificación de formas de aprovechamiento, en la vigencia de muchos de los conocimientos y tecnologías tradicionales y en el gran número de formas de consumo. Esto evidencia la vigencia de estrategias de producción que no apuestan todo a la explotación de un solo recurso ni a una sola forma de aprovechamiento de este recurso. Esta estrategia de diversificación que normalmente se asocia con pueblos atrasados, faltos de desarrrollo y considerados opuestos a la modernización y a la gran apertura de México a los mercados trasnacionales, muestra su mayor importancia precisamente para enfrentar las fluctuaciones de mercados y las dependencias económicas.

Obviamente, los sistemas de la región enfrentan grandes problemas, como insuficiencia de recursos, sobreexplotación y estrangulamientos tecnológicos, pero éstos, más que para descalificar la estrategia, deben servir para apuntalar el diseño de políticas y programas de desarrollo que contemplen integralmente la investigación, la formación de recursos humanos y la promoción comunitaria.

La experiencia ha demostrado que los proyectos que se plantean la conservación y el desarrollo a través de un solo recurso y a expensas del bienestar de la mayoría de la población sólo han traído consigo mayor pobreza, gran pérdida de germoplasma y de conocimiento y tecnologías, además de que han fomentado las prácticas de corrupción y de saqueo, así como el agotamiento de los recursos naturales. Por ello es necesario un proyecto de desarrollo con un fuerte arraigo cultural, que recupere el sentido de aprovechamiento diversificado en el manejo y el destino de los productos, y que se preocupe por identificar esos recursos potenciales que apunten al autoconsumo y a mercados locales, regionales, nacionales e internacioneles diversificados.

Esto implicaría dejar de concebir la estrategia de la diversificación como un paliativo de la pobreza, y darle una proyección alternativa hacia el bienestar. En la medida en que se conciben como proyectos paliativos de pobreza (para controlar el descontento social y la emigración) se producen proyectos marginales que siempre son proyectos pobres hechos para los pobres y para que sigan siendo pobres. Pensarlo de otra manera significa revertir esa tendencia e inyectar grandes cantidades de recursos financieros, tecnológicos y humanos en el desarrollo de sistemas que ya existen. Esta estrategia de diversificación es la que algunos países desarrollados empiezan a considerar.

La estrategia tiene que contemplar por una parte el desarrollo de los mercados de autoabasto local y, por la otra, el de los potenciales mercados nacionales e internacionales. No se pretende que con los recursos locales se llegue a un autoabasto total, sino de tender diferentes puentes de desarrollo. Todo esto tiene que ir acompañado de una planeación que intente desarrollar los recursos de tal forma que no se concentren los recursos más productivos en una sola persona o en grupos, sino hacerlo de la manera mejor distribuida posible.

De aquí se derivan como líneas de investigación:

1. Apoyo a los sistemas de autoabasto con el objetivo de mejorar la calidad de vida (alimentación, vivienda, vestido):
   - leña y estufas eficientizadoras del calor
   - maguey y pastos (para control de erosión)
   - forrajes y silos
   - frutales
   - restauración de los ecosistemas más deteriorados: los bosques y los sistemas acuáticos, con su fauna asociada, de importancia básica para el autoabasto
   - evaluación y revitalización de las prácticas agrícolas tradicionales eficientes
2. Desarrollo de los recursos con mercado potencial (local, regional, nacional e internacional). Como medida práctica inmediata se podría pensar en la creación de una comercializadora especial de productos de la región de la REBMM (miel orgánica, hongos, textiles, tés, plantas medicinales, productos de zacatón, etcétera), y ofrecerla a los gobiernos de Estados Unidos y Canadá como parte de la estrategia para reducir la presión sobre el bosque en esta región.

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Retos para la conservación de los sitios de la mariposa monarca

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El aprovechamiento forestal comunitario en la Reserva Especial de la Biosfera Mariposa Monarca

Mi nombre es Silverio Tapia Torres, soy el presidente del comisariado ejidal de Jesús de Nazareno, municipio de Angangueo, y secretario del Consejo Directivo de la Alianza de Ejidos y Comunidades de la Reserva Mariposa Monarca. Les voy a contar algo de nuestra triste historia forestal.

En el municipio de Angangueo se encuentran tres ejidos, el de nosotros es el más chico. Hace más de 50 años, a 72 ejidatarios el gobierno nos dotó provisionalmente de 74 hectáreas, la mayoría de monte y sólo 24 para agricultura. El monte no lo explotábamos y nuestras tierras eran de temporal y muy delgadas, las sembrábamos un año y las dejábamos descansar a veces hasta dos años; 24 hectáreas eran muy pocas para 72 ejidatarios que poco a poco se fueron saliendo del ejido hasta quedar solamente 23. En 1983 se resolvió en forma definitiva nuestra situación; el gobierno nos entregó 228 hectáreas más de monte, a las cuales casi no les sacamos madera por falta de caminos. Cuando tuvimos permisos forestales fue para tumbar muy pocos árboles.

Para sembrar nuestras tierras tenemos que caminar casi dos horas, y como están cerca del monte a veces nuestra pobre cosecha es para las ardillas, las tuzas y otros animales del bosque. Teníamos además otro problema: era vecino nuestro un militar que mataba el ganado que se metía a su predio y además amenazaba con ampliar su propiedad.

Durante largos 14 años, o sea desde 1984, no sacamos madera de nuestro bosque por la razón que ya dije; cuando en 1986 se creó la reserva de la mariposa monarca abrigamos la esperanza de que nos llegaran algunos beneficios. Pero han pasado los años y estamos perdiendo esa esperanza. En 1990 tuvimos problemas económicos muy fuertes y decidimos tumbar unos árboles sin permiso para resolver nuestras necesidades más urgentes, pero el gobierno se dio cuenta y nos agarró como a delincuentes. Más de un año estuvimos en la cárcel sólo porque tumbamos algunos árboles en nuestro predio para poder sobrevivir. A partir de ahí decidimos esperar a que quienes quieren que se proteja a la mariposa se acordaran también de nosotros, pero hasta la fecha no hemos recibido beneficios que mejoren nuestra situación. Tenemos 110 hectáreas afectadas por la zona núcleo de la reserva y 58 hectáreas en zona de amortiguamiento, o sea, la mayor parte de nuestro predio está afectado por el decreto; allí se han plagado y secado muchos árboles, y sin embargo está prohibido sacar esas maderas.

Esperamos resultar beneficiados por la mariposa monarca porque llega a nuestro bosque, pero no sólo eso, pues además tenemos plantas, hongos, árboles y animales salvajes muy variados, escurrideros de agua y también unos miradores naturales desde donde se ve muy bonito el valle y se vería mejor si se pusiera un malacate como los que salen en la televisión para transportar la gente a los miradores. Pero con todo eso que tenemos no ha sido posible que se pueda aprovechar nuestro bosque para el ecoturismo. Hace mas de once años que el bosque no se quema porque lo cuidamos mucho, aunque no le saquemos madera.

En los últimos años se han muerto algunos de nuestros ejidatarios; pudieron haber vivido un poco más si hubiéramos tenido dinero para pagar un doctor y comprarles sus medicinas, pero se han ido sin haberle sacado provecho a esos montes que tanta lucha les costó conseguir.

Hace casi dos años decidimos solicitar un permiso para sacar la madera de los árboles que se han muerto en la zona de amortiguamiento; se hizo un estudio que se presentó hace casi un año y medio, y allí empezó nuestro desánimo. Primero nos pidieron otro estudio que se llama de impacto ambiental, después tuvimos que pagar impuestos, además hicimos otros gastos en ir a México y regresar, hablar por teléfono, etcétera. Cuando después de mucho tiempo se consiguió la autorización de impacto ambiental tuvimos que esperar el permiso de aprovechamiento que da la oficina de Morelia; otra vez ir y venir y hacer otros gastos hasta que por fin en junio nos entregaron el permiso con un plazo al 15 de julio para sacar las maderas. Nos fue imposible hacerlo porque llegó la temporada de lluvias. Nuestros males se complicaron más, la madera que íbamos a sacar ya estaba muy podrida, pero en cambio había más madera de otros árboles que habían muerto. Para sacar la madera teníamos que solicitar una prórroga, que se nos diera otro plazo. Se ordenó una revisión para que se presentara un informe que dijera que había más madera dañada… total que para cuando eso se resuelva ya no podremos hacer nada porque la mariposa monarca ya estará en la región y el decreto prohíbe la extracción de madera en la zona de amortiguamiento durante el tiempo que la mariposa se queda en nuestra tierra.

La esperanza de sacar algo de provecho de nuestro monte se ha vuelto desilusión; estamos decepcionados y en lugar de ganar dinero con la madera estamos perdiendo. Con razón muchos escogen el camino del clandestinaje. Los malos empleados de las oficinas que provocan esto le hacen mucho daño a las buenas intenciones del Presidente de la República y de la Secretaria del Medio Ambiente. Estamos endeudados porque conseguimos dinero prestado para pagar estudios y los impuestos; se gastó mucho en trámites y ahora ya no sabemos qué hacer ni a quién hacer responsable de nuestros problemas.

Sólo para hacer una comparación que muestra la injusticia cometida contra nosotros, les diré que no lejos de nuestro ejido y también dentro de la reserva existe otra comunidad afectada por el decreto. En 1994 les otorgaron un permiso de limpia y este año les otorgaron otro y se los fueron a entregar personalmente en la comunidad y con muchas otras facilidades. Nuestros hermanos campesinos no tienen la culpa de esto, ellos cumplen con solicitar permiso para aprovechar lo que se puede y que su gente tenga una fuente de trabajo, lo que criticamos son las diferentes formas de trato que algunos funcionarios nos dan a los campesinos, con razón es tan difícil que nos convirtamos en silvicultores.

Nuestros problemas más grandes son: la afectación que nos hizo el decreto en la mayor parte de nuestro predio, sin haber recibido nada a cambio; de nuestra agricultura a veces no sacamos ni lo suficiente para nuestro consumo, y las dificultades que tenemos para sacar madera en lo poco que nos queda libre.

Ya lo hemos dicho muchas veces: si queremos sacarle madera a nuestro monte es por necesidad, pero parece que eso muchos no lo entienden. Hemos dicho también que si no quieren que le saquemos madera al monte, no lo haremos, pero que nos paguen la renta por lo que nos está afectando y además que se autorice la entrada de turistas al santuario de las mariposas por nuestro predio.

Hace cinco años nos metieron a la cárcel por tumbar algunos árboles para sobrevivir; hoy ya no queremos sufrir nuevamente esa experiencia, pero confiamos en que de esta importante reunión resulten conclusiones que ayuden a mejorar la situación de nuestra reserva.

Quiero dejar claro que si la mariposa sufre, nosotros también sufrimos, porque la queremos y la cuidamos. Estamos de acuerdo en proteger y mejorar nuestro bosque y a la mariposa, pero eso quiere decir que todos nosotros, los campesinos, ustedes los que no son campesinos y la sociedad de otros países deben ayudar para que todos juntos logremos tener muchas más mariposas, mucho más bosque y menos problemas en nuestra región.

En nuestra organización, que es la Alianza de Ejidos y Comunidades de la Reserva Mariposa Monarca, estamos convencidos de la necesidad de mejorar nuestros bosques, pero también creemos que es necesario resolver los problemas que son iguales para todos los campesinos de la reserva. Yo estoy seguro de que si juntamos nuestras ideas y buscamos soluciones, pronto tendremos una reserva campesina bien cuidada que nos dará gusto a todos visitar.

Pedimos entonces, a los organismos internacionales y nacionales, apoyo para mejorar las condiciones de la reserva y de sus comunidades campesinas.

La educación ambiental y la mariposa monarca

Aunque mi ponencia no ha sido registrada con ese nombre, en el desarrollo de mi intervención hablaré de la educación ambiental, los proyectos alternativos y la capacitación comunitaria, por ser tres aspectos muy relacionados y por constituir, en mi opinión, el mejor camino para lograr la conservación de la mariposa monarca y el desarrollo regional.

Es un privilegio para nosotros vivir en la región que la mariposa monarca ha escogido para pasar el invierno, región que desde el punto de vista ecológico ha alcanzado fama mundial. Las monarca han logrado que se despierte el interés de gobiernos y organizaciones de muchas partes del mundo, principalmente Canadá, Estados Unidos y México, para procurar su protección y conservación, y en ese sentido se han dado avances importantes, se han creado instituciones, organismos, leyes, estudios, convenios, etcétera. Son también ahora tantos los agentes interesados en su protección que la misma mariposa debe estar sorprendida de la preocupación mundial que se ha despertado por su conservación. También nosotros estamos sorprendidos, pues no obstante que se han realizado muchos estudios sobre su biología y comportamiento, existen aún grandes misterios sobre el fenómeno migratorio de este maravilloso insecto.

Sin duda ha habido grandes avances: el Programa Bosque Modelo, el Plan de Manejo de la Reserva, el Plan de Ordenamiento Ecológico de la región, son algunos botones de muestra. Claro que aún falta mucho por hacer y esta reunión tiene por propósito conocer puntos de vista y propuestas que contribuyan a avanzar más. Aquí muchos hablarán de lo que se ha hecho y otros de lo que se puede hacer, finalmente todos venimos con el propósito de poner nuestro grano de arena para contribuir a la conservación de los recursos naturales de la reserva mariposa monarca.

Pero las monarca, como muchas otras especies vivientes de nuestra naturaleza, también están amenazadas por la alteración que sufre su hábitat, debido al comportamiento inadecuado de muchos seres humanos, y como dice un refrán popular: “El primer paso hacia la cura es conocer la enfermedad”, lo que significa que para resolver los problemas que amenazan a la mariposa es una condición conocer las causas.

Cuando hablamos de proteger a la mariposa monarca siempre creemos que es protegerla de quien realiza acciones directas para dañarla, pero en mi opinión su protección implica acciones más amplias. Protegerla ¿de qué? o ¿de quién?

- Protegerla del funcionario chambista, prepotente e ignorante, golondrino, que actúa irresponsablemente siguiendo el criterio de que “el que venga atrás, que arree” o, en otras palabras, “el que venga después de mí, que resuelva el problema”.
- Protegerla del empresario forestal de visión estrecha que en aras de una rentabilidad inmediata y fácil contribuye al deterioro de los bosques y otros recursos naturales.
- Protegerla del reportero amarillista que en un afán mercantil desinforma, desorienta, confunde y alarma a la población.
- Protegerla del ecologista a ultranza que sin conocer la dinámica de la naturaleza genera propuestas muy alejadas de la realidad.
- Protegerla del político oportunista que asume poses de protector de la mariposa con claros fines políticos.
- Protegerla del científico egoísta que adquiere grandes conocimiento sobre la mariposa pero los maneja como propiedad privada.
- Protegerla de los técnicos irresponsables que con su ineptitud se vuelven cómplices de los depredadores de bosques.
- Protegerla del turista inconsciente que daña la naturaleza porque no la conoce.
- Protegerla del campesino menesteroso que la destruye porque no le queda otro camino para lograr su sobrevivencia.
- Protegerla del ciudadano indiferente para quien la conservación del medio ambiente es algo romántico y ridículo.

En general, la mariposa debe protegerse de todo aquel que directa o indirectamente contribuye a crear condiciones que repercuten negativamente en su conservación. Por eso protegerla requiere un cambio de aptitud y un cambio de actitud, que deben ser producto de una serie de acciones, entre ellas la educación ambiental. En esta ocasión sólo hablaré de lo que en la región puede hacerse para tener un comportamiento conservacionista de los recursos naturales.

Para que la planeación y la participación comunitaria se den es necesario que se promueva una educación ambiental de amplia base popular. En las escuelas, en las comunidades rurales y en la sociedad en general tiene que establecerse un programa intensivo sobre el tema.

Tratar a la naturaleza requiere de conocimiento para evitar que se le haga daño, daño que finalmente se revierte a la humanidad. Adquirir ese conocimiento no es fácil, menos aún cuando ese conocimiento es monopolio de unos pocos.

La falta de conciencia ambiental es el lógico producto del monopolio de este conocimiento. Desde hace años nuestro país y otros países han gastado enormes sumas de dinero para estudiar a la mariposa y todo ese conocimiento ha quedado prácticamente sólo en manos de especialistas. Es un caso de propiedad privada de conocimientos adquiridos con fondos públicos, que salvo honrosas excepciones, sólo muy superficialmente se proyectan a la sociedad, generando así una educación ambiental de carácter muy elitista.

El desequilibrio informativo y educativo es insultante dada la gran cantidad de dineros públicos que se han invertido en educación e investigación. La brecha en conocimiento se convierte en brecha de participación y de capacidad de decisión.

En la región, a más de diez años del decreto, un muy alto número de dueños de los recursos naturales y habitantes de la región desconocen los límites de la reserva, las superficies que comprende, los predios afectados, la ubicación de las colonias de invernación, etcétera. A más de 20 años del descubrimiento oficial de los santuarios, un muy alto porcentaje de la población en general desconoce las cuestiones más elementales sobre la conservación de la mariposa.

Conservar los bosques es conservar la mariposa monarca y son los bosques el elemento principal del ecosistema de esta región. Ellos son también absolutamente indispensables para un medio ambiente de buena calidad. Si no conocemos los beneficios que obtenemos del bosque es también por falta de esa información.

Los bosques no solamente mejoran el paisaje, sino que están ligados al clima, al agua, al suelo, a la agricultura, a la ganadería, a la industria y a muchas actividades más. Estos aspectos son esenciales en el desarrollo de la región y del país mismo. El destino de los bosques nos afecta a todos y, por lo tanto, verlos con indiferencia o con apatía es una expresión de atraso y de ignorancia, y todo es por falta de información.

Sólo en la medida en que haya educación ambiental podrá haber condiciones para dejar el cuidado de la reserva bajo responsabilidad de los dueños de los bosques y los habitantes. Se hace necesario entonces que en esta región el programa de educación ambiental contemple la creación de un centro educativo exclusivo para este fin, un medio informativo local sobre aspectos ambientales, un museo que exhiba la riqueza natural de la región, eventos enfocados en el mismo propósito y un amplio programa de información, análisis y discusión a través de los diferentes medios de comunicación local.

El interés por el ambientalismo pronto hará que nuestro país se inunde de biólogos, corriéndose el riesgo de que en un tiempo se cuente con un "ejército de generales". Para que esto no suceda y la información ambiental llegue a todos, tiene que promoverse la formación de los promotores ambientales que involucren a la gente de la región. El destino de la reserva tiene que quedar entre quienes aseguren la continuidad de los programas, no entre los funcionarios de paso; éstos no nos interesan, muchos han venido y ya no están aquí, no saben qué pasó ni les preocupa, para nada nos sirve la experiencia que adquirieron. En cambio, si gente de la región se involucra, todo se quedará aquí aumentando nuestra experiencia, aumentando nuestro conocimiento y enriqueciendo nuestra cultura sobre la naturaleza. Para lograr eso debe crearse un mecanismo de detección de capacidades y establecer un procedimiento de selección, entrenamiento, supervisión y evaluación para procurar normas de calidad profesional. De esta manera se lograría un mejor aprovechamiento de las capacidades con que cuenta la región y no estaríamos desperdiciando hombres y mujeres capaces que no se desarrollan ni sobresalen por la presión de grupos con claros intereses egoístas. Esto tendría otro impacto positivo, pues los gastos de nómina se reducirían y permitirían incrementar los recursos para proyectos productivos comunitarios.

La educación ambiental mejorará cuando los expertos hagan a un lado su egoísmo, su temor a perder la chamba y su miedo a la competencia. La competencia permitirá la superación, hay campesinos con conocimientos prácticos que ya empiezan a destacar, pronto habrá más competencia que beneficiará a la región. La educación ambiental permitirá así romper vicios y costumbres antiecológicas.

La indiferencia ecológica con la que actuamos muchos mexicanos se resume en esta anécdota sobre el manejo de los bosques: hace unos años, en un curso profesional de manejo forestal, un asistente señaló al instructor finlandés: “Si ustedes trabajaran en México no tendrían los mismos resultados que en Finlandia: el campesino mexicano es un voraz destructor de bosques”. El instructor finlandés contestó: “Hay una razón y se las diré: Yo he visto en jardines de este país plantitas de maíz que crecen como mala hierba y nadie las toca; aunque no sirvan ni de adorno, se les tiene un respeto casi religioso. ¿Por qué?, porque esa plantita, o sea el maíz, ha dado y sigue dando la vida a muchas generaciones de mexicanos. A nosotros la vida nos la dan nuestros bosques, por eso les tenemos gran respeto y cariño. Cuando el campesino mexicano viva de sus bosques, los cuidará igual o mejor que nosotros”.

Por eso conocer la naturaleza y aprovecharla sin ocasionarle daños, respetando sobre todo sus leyes naturales, es una tarea de todos. Los promotores de estas tareas deben ser hombres de cambio, con principios sólidos, convencidos de que la conservación y protección de la mariposa monarca depende del bienestar de los dueños y habitantes de esta región. Quienes intenten estas tareas no están solos, los respalda un ejército de campesinos y ciudadanos con un gran deseo de adquirir conocimientos para crear una nueva relación con el bosque.

Pero la educación no lo es todo, como ya dije. Por sí sola poco puede lograr en donde existe hambre, tiene que ir acompañada de la búsqueda de otras alternativas económicas acordes con los recursos naturales existentes y el sentir de las comunidades y un gran programa de capacitación, para no volver a cometer errores pasados. En la región hay una gran cantidad de recursos naturales poco aprovechados, otros mal aprovechados y otros sin aprovechar; esto no significa dejar de aprovechar los bosques, porque ustedes, yo, nosotros necesitamos productos de la madera, empleos, ingresos; pero también necesitamos agua, clima, oxígeno. Necesitamos conservar aprovechando, porque no aprovechar los bosques tampoco es una medida de conservación. Para muestra basta un botón: en la reserva, los bosques de la exhacienda de Chincua y de buena parte de las áreas núcleo, después de más de diez años de no aprovecharse, presentan un estado de madurez y envejecimiento que está provocando una gran mortandad de árboles de todos tamaños. Lo que sí tenemos que hacer es manejar el bosque procurando mantenerlo en las condiciones que la mariposa monarca requiere para su invernación; los investigadores seguramente nos dirán que sí es compatible el aprovechamiento del bosque y la vida de los campesinos con la conservación de la mariposa monarca.

Si la región presenta un problema de deterioro de los recursos forestales debemos tener muy en claro las causas. En mi opinión, el deterioro de los bosques:

- No es un problema de falta de vigilancia por parte de las dependencias competentes; es un problema de falta de silvicultores.
- No es un problema de demanda de madera, sino de falta de estímulos y esquemas para incentivar su producción a través de plantaciones.
- No es un problema de falta de participación campesina; es un problema de rentismo generado por falta de organización, capacitación y capitalización para ser silvicultores.
- No es un problema de bajas utilidades en la comercialización de las maderas, sino de los altos costos de producción, pues no hemos sido capaces de operar con altos niveles de eficiencia y calidad, simplificar los aspectos administrativos y buscar formas de asociación provechosas.
- No es un problema de falta de mercados para los productos forestales, sino de escasa diversificación y un porcentaje muy alto de empresas dedicadas sólo a la producción de tablas.
- No es un problema de exceso de capacidad instalada; es un problema de falta de planeación y modernización de la industria forestal.
- Es un problema de alta población, pobreza y analfabetismo, pero también es un problema de inadecuado aprovechamiento de los recursos naturales y de inequitativa distribución de la riqueza.

El problema en la zona es muy complejo, es cierto, pero si todos actuamos en forma ordenada y coordinada lograremos avances importantes. En la región hay grandes oportunidades de desarrollo. Estamos cerca del mercado más grande del país; hay una gran cantidad de recursos naturales que se pueden aprovechar; hay un enorme potencial productivo de los suelos de nuestra región; hay un gran interés del gobierno por desarrollar la zona, y una gran disposición de los productores por involucrarse en este proceso.

Entre las alternativas más importantes están el ecoturismo, la acuacultura, la agroforestería, las plantaciones forestales para usos múltiples, la producción de árboles navideños, el establecimiento de criaderos de venado, la explotación de minas de mineral, arena, piedra, canteras, el aprovechamiento de plantas medicinales, hongos, semillas, resinas, la fabricación de artesanías, la fruticultura, la apicultura, la creación de pequeñas empresas forestales para industrializar la madera, una gran riqueza arqueológica y también un gran patrimonio histórico.

Diseñar y aplicar las estrategias adecuadas es otro aspecto que se deberá abordar bajo la responsabilidad de los órganos de consulta y decisión que ya se están integrando en la región.

Diversificar las actividades productivas requiere necesariamente de un gran programa de capacitación que permita que los involucrados desarrollen capacidades que los conviertan poco a poco en gestores de su propio destino.

Por último, hay gran capacidad para hacer planeación, pero cuando de la ejecución se trata las capacidades se reducen drásticamente. Para evitar que esto se convierta en un cuello de botella es necesario multiplicar las capacidades sobre todo en aquellas tareas que no tienen por qué ser realizadas por profesionales. El centro de educación ambiental propuesto podría incluir también la formación en técnicas comunitarias.

La educación ambiental, los proyectos alternativos y la capacitación lograrán sin lugar a dudas el mejoramiento del nivel de vida de la población que vive en la región. Esto permitirá reducir la presión sobre los bosques, disminuir la migración de los jóvenes, recuperar las áreas degradadas, proteger la biodiversidad, lograr estabilidad y paz social, y confianza y credibilidad en las acciones de gobierno.

Todos, en mayor o menor medida, obtenemos beneficios de nuestro medio ambiente; todos tenemos el compromiso de asumir una actitud de respeto hacia la naturaleza. Cuando esto suceda, este tipo de reuniones será para celebrar que los bosques, las mariposas monarca y los humanos vivimos en armonía.

Capítulo/Chapter 4

Educación ambiental
Environmental Education

Anónimo
"Debemos de hablar solamente un lenguaje, y ése debe ser el del campesino. Si continuamos hablando lenguajes diferentes nunca nos entenderemos y jamás resolveremos los problemas."

Rosie Emery
"When we look at the aspirations of environmental education (awareness, knowledge, skills, attitudes and participation), we have a lot of awareness. We have a lot of knowledge. We have a lot of skilled people out there, but as for attitudes and participation, there is not an awful lot...Without the attitudes and participation you don't get the change in behavior, which is what we really want to see. In other words, if the children don't really feel a connection to the earth, they're not going to grow up into people who take that much care of it."

Liz Goehring
"We really learn best that which we have to teach ourselves."

Introducción

por ***Steven Price***
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La mayoría de los habitantes de América del Norte identifica a la mariposa monarca. De hecho, es la única mariposa que casi todos reconocen. Entre los insectos —grupo enorme de especies no siempre populares entre la gente—, la monarca es luminosa, intrépida y hermosa. Incluso entre las mariposas, las monarca son deslumbrantes: las orugas lucen rayas negras y amarillas; las crisálidas, un verde turquesa con manchas doradas, y las adultas un subido naranja.

No por azar las monarca se convirtieron en algo clásico en los salones de clase y círculos de estudio de historia natural. Criar una mariposa es un proyecto tan sencillo como cautivador. Su transfiguración demuestra la adaptación esencial de muchos insectos: el aprovechamiento de los diversos entornos ambientales durante las diversas fases de su ciclo de vida. La bien conocida dependencia de las orugas del algodoncillo como alimento ilustra la relación huésped-hervíboro. La adquisición de defensas tóxicas invisibles de la planta huésped revela que la evolución puede lograr mucho más de lo que podemos percibir a primera vista.

Tal reputación, aunada a la extraordinaria migración anual de la monarca —una criatura con el peso de un botón que vuela más de tres mil kilómetros y que durante muchas generaciones se ha orientado con una brújula inherente no visible—, llena de asombro y admiración a jóvenes y viejos, maestros y estudiantes, científicos y agricultores. Esa conciencia sin paralelo sobre una especie migratoria da a los conservacionistas una extraordinaria oportunidad de cooperación internacional para salvaguardar a la monarca. Y si Canadá, Estados Unidos y México logran asegurar el futuro de esta mariposa, cientos de especies de aves migratorias que, al que igual las monarca, no reconocen como fronteras el río Bravo ni el paralelo 49, tendrán también posibilidad de beneficiarse. ¡Qué peso tan enorme sobre alas tan delicadas!

Belleza, familiaridad, fidelidad, lealtad, transfiguración, invencibilidad, inmigración, descubrimiento… con sobrada razón nos fascinan tanto las monarca.

Por ventura, la reunión gozó de la presencia de participantes de gran importancia que desarrollan y conciben a la mariposa monarca como un símbolo del vínculo y la interdependencia entre Canadá, Estados Unidos y México:

- Rocío Treviño Ulloa informa sobre el éxito del proyecto Correo Real, un emprendimiento de Protección de la Fauna Mexicana, asociación civil que educa en torno de las mariposas monarca a estudiantes de México en sus salones de clase, en el bosque y durante la inmigración.
- El profesor Orley “Chip” Taylor de la Universidad de Kansas explica las actividades y el éxito de Monarch Watch, colaboración de científicos, estudiantes y voluntarios que estudian, vigilan y realizan actividades de conservación de la mariposa monarca en laboratorios, salones de clase, el campo y a menudo en Internet.
- Elizabeth Donnely comparte el enorme interés que ha generado la Jornada hacia el Norte (Journey North) en más de 100 mil escuelas en toda América del Norte, pues los estudiantes siguen la emigración de las monarca de país a país y presentan sus observaciones locales en un mapa dinámico compartido en Internet con otros estudiantes.
- Karen Oberhaouser y Liz Goehring, de la Universidad de Minnesota, describen cómo el programa Monarcas en el Aula (Monarchs in the Classroom) promueve la ciencia en las escuelas, la investigación conjunta entre los estudiantes y los científicos, y la conservación en las praderas locales.
- Craig Tufts, de la National Wildlife Federation, describe cómo su red de personas, escuelas y empresarios en América del Norte puede apoyar la conservación de las monarca y el algodoncillo.
- Michelle Prysby y Karen Oberhauser demuestran que los voluntarios bien entrenados pueden realizar un monitoreo del algodoncillo y de las poblaciones de monarca durante la estación de reproducción, un resultado que responde a la necesidad prioritaria de investigación identificada por los científicos durante la conferencia misma.

- Jean Lauriault ilustra cómo el Canadian Museum of Nature ha capitalizado la historia de la monarca para emprender la educación a través de las fronteras internacionales.
- Donald Davis, un canadiense naturalista aficionado y defensor de la monarca, documenta la concepción, el nacimiento y el crecimiento del Jardín de Mariposas Urquhart (Urquhart Butterfly Garden), ubicado en Dundas, Ontario, así denominado en honor de Frederick y Norah Urquhart, pioneros en la investigación de las mariposas monarca.
- Leonardo Meza Aguilar aborda la experiencia acumulada de la participación comunitaria con las mariposas monarca en México para comenzar a analizar y evaluar los programas de educación ambiental que tienen por objeto a las monarca.
- Ana María Muñiz Salcedo, Guadalupe del Río Pesado, Gabriel Sánchez Ledezma y Elia Hernández Saldaña abordan la preocupación básica de lo que constituye la participación significativa y de largo plazo de las comunidades en las decisiones respecto a la investigación sobre el manejo de las reservas.

La reunión confirmó la persistencia de las monarca en nuestra atención, al margen de la nacionalidad, y nos recordó por igual a científicos y campesinos la necesidad de ayudar a salvarla.

Introduction

by ***Steven Price***
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Most North Americans recognize the monarch butterfly. In fact, for most people, it is the *only* butterfly that they know. Among insects—an enormous group of species not always popular with the public—the monarch is bright, bold and beautiful. Even among butterflies, the monarch dazzles: black-and-yellow striped caterpillar, turquoise green chrysalis trimmed with gold fleck, and fiery orange adult.

For good reason, monarchs have become a reliable feature of classrooms and natural history clubs. Rearing a butterfly is a simple and captivating project. The transfiguration of the butterfly demonstrates a key adaptation of many insects: exploitation of different environments during the different stages of its life cycle. The caterpillar's well-known dependence on milkweed for food exemplifies the host-herbivore relationship. The butterfly's acquisition of invisible toxic defences from its host plant reveals that evolution can accomplish much more than what we can immediately see.

Coupling this reputation with the monarch's extraordinary annual migration—a creature with the weight of a button flying over 3,000 kilometres using a compass inherited but not deployed for several generations—sparks wonder and awe in young and old, teacher and student, scientist and farmer. Such unparalleled awareness for a migratory species provides conservationists with an extraordinary opportunity for international co-operation to safeguard the monarch. And if Canada, the United States and Mexico succeed in securing the monarch's future, hundreds of migratory bird species that, like the monarch, recognize neither the Rio Grande nor the 49^{th} parallel as barriers, stand to benefit, too. What enormous weight such delicate wings carry!

Beauty, familiarity, fidelity, royalty, transfiguration, invincibility, migration, discovery—no wonder we are so fascinated with monarchs!

Fortunately, the conference benefited from the attendance of key players who are developing and using the monarch butterfly as a symbol of the linkage and interdependence among Mexico, the United States and Canada:

- Rocío Treviño Ulloa reports on the success of *Proyecto Correo Real*, a program of *Protección de la Fauna Mexicana*, A.C., which is exposing students in Mexico to monarchs in their classrooms, in the forest and during migration.
- Prof. Orley "Chip" Taylor of the University of Kansas explains the activities and success of "Monarch Watch," a collaboration of scientists, students and volunteers who study, monitor and conserve the monarch butterfly in the laboratory, classroom and field and frequently over the internet.
- Elizabeth Donnelly shares the explosion of interest that "Journey North" has generated in over 100,000 schools across North America, as students track the migration of monarchs from country to country by submitting their local observations to a dynamic map shared on the internet with other students.
- Karen Oberhauser and Liz Goehring of the University of Minnesota describe how the "Monarchs in the Classroom" program promotes science in schools, collaborative research among students and scientists, and conservation in local meadows.
- Craig Tufts of the National Wildlife Federation outlines how its network of individuals, schools and corporate members across North America can support conservation of monarchs and milkweeds.
- Michelle Prysby and Karen Oberhauser demonstrate that properly trained volunteers can provide continent-wide monitoring of milkweed and monarch populations during the butterfly's breeding season—a result that responds to a high priority research need identified by scientists during the conference itself.

- Jean Lauriault illustrates how the Canadian Museum of Nature has capitalized on the monarch's story to pursue education across international boundaries.
- Donald Davis, an amateur naturalist and Canada's champion of the monarch, documents the conception, birth and growth of the "Urquhart Butterfly Garden," located in Dundas, Ontario and named after Frederick and Norah Urquhart, pioneers in monarch migration research.
- Leonardo Meza Aguilar draws on the accumulating experience of community involvement with monarch butterflies in Mexico to begin analyzing and evaluating environmental education programs that feature the monarch.
- Ana María Muñiz Salcedo, Guadalupe Del Río Pesado, Gabriel Sánchez Ledezma and Elia Hernández Saldaña address the vital concern of what constitutes long-term, meaningful participation of communities in resource management decisions in the reserves.

The conference confirmed the enduring hold that monarchs have on our attention, regardless of our nationality, and reminded scientist and farmer alike of our need for each other's help to save it.

Journey North: Tracking the migration over the internet

by ***Elizabeth Donnelly***
Journey North
Wayzata, Minnesota, United States

Journey North is a science education program in which students track wildlife migration over the Internet. As the spring season advances across North America, participants track spring's "Journey North," thus the program's name (see: www.learner.org/jnorth). Now in its 5th year, Journey North reaches over 100,000 students who are based in schools across Canada, the US and increasingly in Mexico as the technology becomes available.

By sharing their own field observations of migratory species and signs of spring, students literally watch the food chain come back to life each spring. They observe how the season touches everything in its path, from the smallest butterfly to the greatest whale. As sunlight increases during spring, a huge flux of energy is delivered into the system. Temperatures rise and plants begin to grow. Next, the animals that eat plants arrive on the scene, and then their predators—and so on, up the entire food chain. Students make local observations and fit them into a global context. They see their ecosystem working in their backyard, but they understand it on a global scale.

As science educators, one of our most important goals is to cause students to wonder, to ask questions and to want to investigate reasons why. The incredible stories of animal migration are an ideal vehicle to stimulate inquiry. After all, these are survival stories, full of wonder and mystery: How does the robin make its way to its nest in my backyard each spring? How is a tiny songbirds capable of an 18-hour, non-stop flight across the Gulf of Mexico? And of course, how in the world does the monarch butterfly find Mexico's Trasvolcanic Mountains each fall—a place it has never been, and yet the exact same place its great grandparents left the previous spring?

Citizen science

The Internet makes it possible for citizens to assist scientists in field research, and it's the ideal tool for collecting migration information. In fact, without this technology it is not possible to collect field observations on a real-time basis, from hundreds of observers who are spread across a broad geographic range—and to do this at very low cost.

Results from tracking the spring monarch migration illustrate how beautifully the system works: Field observers report the FIRST monarch butterfly they see in the spring. As these observers report in from the south and then from points further north, we're able to follow the wave of migration as it moves northward. But does it actually more northward? Here is where the data get interesting.

As our maps of the spring migrations show, the monarchs clearly move up the US East Coast far earlier than they move into the Midwestern States (see: www.learner.org/jnorth). The pattern is especially clear when the distance from Mexico is considered. In fact, in 1997, monarchs appeared at latitudes on the East Coast a full 5–6 weeks earlier than they did at the same latitudes in the Midwest.

Students were asked to interpret these findings, and the response of one 3rd grade illustrates the high level of scientific reasoning students develop through this study. These young students noticed that the monarch data reflected the same geographic pattern as did the Journey North tulip garden data. (Students plant tulips to serve as an measure of spring's progress. Several hundred tulip gardens were planted across the US and Canada.) The tulip gardens served as a measure of vegetative growth in North America last spring, and the results showed vegetation in the Midwest lagging behind that on the East Coast. The 3rd grade students considered the monarchs' dependence on milkweed, and knew plant readiness in spring was of critical importance to the monarchs' reproductive strategy.

In addition to collecting data from observers, Journey North utilizes WWW-based meteorological resources to help students see connections between weather, climate and migration. This area holds exciting promise for education, as well as for science. Never before has meteorological data been so readily accessible at such low cost. Real-time meteorological data, coupled with real-time field data collection offers a tremendous opportunity for learning.

Symbolic Monarch Butterfly Migration

On the opposite end of the spectrum, a low-technology, very human connection has been established between the children of Mexico, the United States and Canada through the Symbolic Monarch Butterfly Migration , a joint project of Journey North and Mexico's Children's Museum, "Papalote." We set out to give students a personal experience that would help them realize the interdependencies of Canada, the US and Mexico and the joint responsibility for monarch conservation. Thus was born the Symbolic Monarch Butterfly Migration, an annual celebration by students of our three countries.

Each fall, students across the US and Canada create paper butterflies that "migrate" to Mexico for the winter. The fall flight is timed to correspond with the real monarchs' journey south. Mexican students care for the butterflies during the winter months. In the spring, when the real monarchs' departure from Mexico is announced, the paper butterflies return to North America. Each butterfly carries a special message of conservation between the children of the 3 countries.

When we began in September, 1996 we had no idea what kind of response to expect. To our great surprise, some 40,000 butterflies arrived in the mail in the space of 10–15 days. The postman actually had to bring a special truck to deliver them one day. With an equal number of Mexican students participating, a staggering 80,000 students across North America contributed to this effort.

Included in these numbers are the Mexican children who live in the communities which surround the monarch sanctuaries. The Symbolic Migration is helping them to see the importance of their place, and to realize that it is a world treasure. Great pride results in knowing that children across North America know about them and care about the butterflies. This celebration symbolizes an international partnership between children of Canada, the United States, and Mexico. Joined by a fragile butterfly, shared hope is carried across borders and between generations.

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Monarchs in the Classroom: A K-12 ecology education program

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Abstract
Monarchs in the Classroom is a K-12 ecology education program designed around an in-depth study of the monarch butterfly. The program involves a cooperative network of scientists, teachers, graduate students and pre-college students, with connections to the Monarch Watch program and monarch-based education throughout North America. Program components include providing live monarchs to classroom teachers; development and dissemination of grade-specific curriculum materials; teacher training; and research partnerships between students, scientists, and pre-college teachers.

Introduction
Picture a classroom of eight-year-olds silently gathered around a table, watching with their mouths wide open as a monarch butterfly emerges from its pupa. Each day for almost two weeks, these students fed, observed, measured and cared for their own caterpillars and then waited another 10 days for this moment. In the process, these students became experts on a fascinating organism, both through their own observations and inquiries, and through the instruction of their teacher who integrated monarchs into science, math, reading, social studies, and art lessons. Later in the day, the students tag and release their monarch as part of an international research project on migration, thus contributing to the body of knowledge about monarch biology as they learn about research. As they follow their monarch's amazing migration south to another country, they learn about a culture very different from their own and begin to think about how eastern North American monarchs depend on the actions of an international citizenry. In the spring, they will check Internet sources for monarch sightings, search the ground for milkweed shoots, and anxiously await the return of monarchs to their area. This is Monarchs in the Classroom.

More formally, Monarchs in the Classroom is a science outreach program from the University of Minnesota, Department of Ecology, Evolution & Behavior. The program has four primary goals: 1) to help to make science more accessible and purposeful for students by bringing science to life in the classroom, 2) to increase students' understanding of biological and ecological principles, 3) to promote research collaboration between students, researchers and educators, and 4) to promote understanding of conservation issues through student connections with monarchs.

The first two of these goals relate directly to current US science education objectives. In recent years, an increased focus on K-12 (kindergarten to grade 12) science instruction has resulted in the development of Benchmarks for Science Literacy (AAAS 1993), National Science Education Standards (National Research Council of the National Academy of Science 1996), and individual state science standards. While these efforts vary in their foci, each stresses the importance of teaching science as a process—promoting a scientific literacy in which students are able to "ask, find, or determine answers to questions derived from curiosity about everyday experiences," and "describe, explain, and predict natural phenomena" (National Research Council of the National Academy of Science 1996, p. 22). Another objective of these standards is reducing the breadth of coverage in science education and covering the core material more thoroughly; in other words, replacing the mile-wide, inch-deep approach typical of science textbooks with an inquiry-based approach. The overriding objective is to teach students to think and discover for themselves—to promote the process of inquiry and discovery used by scientists to understand natural phenomena.

Students involved with Monarchs in the Classroom are afforded the opportunity to study one organism in depth, learning enough about monarchs to generate their own ideas and questions. While an extensive science education program centered around a single insect may seem a bit narrow, this focus has proven to be extremely successful and popular with teachers and students. Monarchs are familiar, well-loved insects that provide a fascinating, non-threatening experience with living organisms. Their easily-observed life cycle brings exciting science concepts to life, and their large size makes it easy for students to handle all life stages. Since monarch larvae feed on milkweed, common even in urban settings, students can collect their food from the surroundings, enabling important connections with the environment. Working with living organisms in the classroom engages students, and allows them to conduct simple investigations, thus practicing observation, hypothesis testing, data collection and analysis. Finally, studying monarchs is especially appealing because it captures the interest and attention of all students, not just those with an aptitude for science. All students become equally involved with this program.

When science is taught as a process rather than a body of knowledge, it is important that teachers have experience with the process of science. Unfortunately, few pre-college teachers have themselves been taught in the way they are being asked to teach their students (Druger and Allen 1998). Our third goal of promoting collaborations between students, teachers and scientists aims at improving this situation. Working scientists have a great deal to offer during this transition in science teaching, and can work in partnership with K-12 educators. Partnerships can take many forms: scientists may help with special projects in their children's schools (science fairs, career days, classroom visits); scientists may partner with teachers to co-develop curriculum and outreach programs for K-12 classrooms; and scientists can involve educators in research, extending the range of the research while affording teachers invaluable experience. Monarchs in the Classroom, along with Monarch Watch (Taylor this volume), has explored each of these avenues (see below) and has evolved into a true K-12/University partnership.

Our fourth goal of promoting an understanding of conservation issues is relevant to environmental education objectives. The development of standards for environmental education at both national and state levels (e.g., State of Minnesota 1993) is an indication of the growing importance of this area in the eyes of education policy makers. While scientific knowledge, particularly an understanding of ecological systems, is integral to environmental education programs, other important components include: 1) an understanding of how social systems interface with environmental issues, and 2) the need for individual stewardship. Both the capacity and the commitment to engage in pro-active stewardship must be developed in students, and commitment is much more likely to result from programs that instill a sense of connection between students and the natural world. Students rearing monarchs make these connections and the monarch's conservation story naturally unfolds for them, giving meaning to these complex and often distant issues.

Program components

Instructional materials

Monarchs in the Classroom began six years ago when we gave extra monarch larvae to a local elementary school, larvae left over from our summer research on monarch reproduction. Today, providing monarch larvae and eggs to teachers is still an important component of the program. In the fall of 1997 we distributed over 7,500 larvae, with most teachers receiving 10 to 20. Most teachers receive the larvae at the beginning of school, use wild milkweed to feed them, and release the adults back into the environment soon after they emerge.

Key to our program is a comprehensive written curriculum that leads teachers and students through an inquiry-based study of monarch butterflies (Monarchs in the Classroom 1997). This curriculum is the result of a three-year collaboration with several Minnesota teachers, who piloted most of the lessons in their classrooms. Our second edition consists of three separate guides (for K-2, 3–6, and Middle School teachers), each of which is over 180 pages long. With its foundation in life science, the curriculum also incorporates concepts and skills in math, reading, writing, art and social studies. Lessons are congruent with pre-college concept and process standards as outlined in the National Research Council of the National Academy of Science's *National Science Education Standards* (1996). The Minnesota Framework for Math and Science Standards (SciMath 1997) showcases the program as an exemplar way of covering life science standards in grades 5–8. Each curriculum guide includes an extensive background section on monarch biology and suggestions for raising monarchs in classrooms, six subject sections of classroom lessons (life cycle, migration

& overwintering, ecology, systematics, experimentation, and conservation), an extensive bibliography, and many student handouts. Lessons range from outdoor observations and class discussions to art projects and games. Table 1 lists the lessons in the Middle School ecology section, as a sample of the breadth of topics covered.

Table 1 — Middle School ecology curriculum: Lesson index topic*

Topic	Lesson	Type
Habitat	1. Butterfly habitat survey	Outdoor observation, art
	2. Make a plant field guide	Outdoor observation, art
	3. Make a butterfly and moth field guide	Research, art, bookmaking
Population Growth	4. How many grandchildren?	Discussion, math
	5. Why isn't the world overrun with monarchs?	Discussion
	6. Mortality in classroom and wild monarch larvae	Observation, data analysis
	7. Monarch Mishaps: A game of survival	Outdoor (or gym) game
Defenses	8. How living things protect themselves	Brainstorming discussion
	9. Plant defenses	Observation, art
	10. Butterfly coloration, Camouflage – 1: Hide a butterfly	Observation, outdoor game, discussion
	11. Butterfly coloration, Camouflage – 2: Toothpick prey	Outdoor game, data analysis
	12. Butterfly coloration: Warning coloration	Discussion, observation, art
	13. Butterfly coloration: Startle Coloration	Discussion, observation, art
	14. Butterfly coloration: Mimicry	Taste-test, discussion
	15. Monarch protection	Observation

* from Monarchs in the classroom: an inquiry-based curriculum for Middle School (1997): 115

We have developed additional support materials, including a monarch caterpillar field guide (Oberhauser & Kuda 1997), which shows readers how to distinguish the five larval instars; two scripted classroom slide sets, one on the monarch's yearly life cycle and one on overwintering biology and conservation; and a board game. The slide sets each consist of 23 separate images, most of which were taken from our research on monarch butterflies.

Teacher workshops

For over three years, we have offered a variety of workshops and courses for teachers. Our most intensive course is a ten day (six hours per day) summer course. This offering is structured to meet over the course of a month to enable teachers to rear larvae and practice their own investigations between the weeks we are in session. The first week is a crash course in monarch biology and research with field and lab experience. The emphasis is to make teachers comfortable with the body of scientific information on monarchs as well as with the process of scientific investigations. During the second week, we focus on translating this knowledge to the classroom. Teachers work in grade level groups (K-2, 3–6 and Middle School) and practice lessons they will use with students. Throughout the course, we model scientific inquiry methods and emphasize the importance of involving students in inquiry activities. Our own research projects illustrate the processes of science—observation, question asking, hypothesis formation, and experimental design. We also teach basic ecological techniques such as population censusing. Each teacher designs and carries out a simple individual or small group experiment, and takes part in class research projects. In addition to the increase in science knowledge and skills gained by teachers, an important outcome of this intensive course is the science education partnerships that develop between educators and researchers. These relationships are maintained after the course ends with formal and informal contacts.

For teachers who can not make the time commitment of the summer course, we offer short (one to seven hour) workshops for individual schools or school districts. In these shorter format workshops, we provide instructions on successfully rearing monarchs in the classroom and guide teachers through the curriculum. In most cases, each participant receives a curriculum guide and ten larvae. Many of the workshops are co-taught with teachers who have taken the longer summer course. The short workshops also provide an important means of disseminating our program.

Finally, we offer a mid-winter one-day teacher reunion for all workshop participants. This meeting affords teachers the opportunity to share experiences from their classrooms as well as hear updates on monarch migration, research and conservation efforts. A true sense of collegiality is fostered through these reunions.

Student/teacher/scientist research

Promoting student and teacher research is a central component of our program. We do this in two ways, by helping teachers to facilitate research projects with their students, and by developing and promoting research projects in which the public can participate.

In workshops and in the written curriculum, we stress the importance of student research and provide instruction on conducting scientific investigations. The curriculum includes step-by-step directions for taking students through the process of designing and carrying out independent research projects. In 1997, we offered a special teacher workshop on developing independent student research projects, which were then carried out in the fall. Participating students were invited to a Monarch Fair held at the Science Museum of Minnesota. They presented posters describing their work to monarch scientists and then left their posters on display for general museum visitors. Research projects were diverse in topic and quality, and included both observational studies (e.g.*, When do monarch butterflies emerge most often over a 24-hour period?*) and experiments (e.g., *Does the condition of milkweed affect larval growth?*). Students, teachers, parents, and other museum guests were enthusiastic about the Monarch Fair, and this program provides a model for future single-topic research fairs for students.

Several large-scale, collaborative research efforts have been developed on monarch butterflies, and the educational potential of these projects is immense. The monarch monitoring project (Prysby & Oberhauser this volume), the Monarch Watch tagging and other research programs (Taylor this volume; Calvert and Wagner this volume), and tracking the spring migration with Journey North (Donnelly this volume) involve students, teachers, and other interested individuals in important research efforts that add to our understanding of basic monarch biology as they teach science. We encourage all of our teachers to participate in as many of these exemplary collaborative research programs as possible.

Project maintenance

Monarchs in the Classroom is disseminated in several ways: electronically on the Monarch Watch website (Taylor this volume), through presentations at state and national meetings for educators, and by word-of-mouth through teacher networks. Although we limit distribution of living materials to teachers in Minnesota and Wisconsin (see Brower et al. 1995), our curriculum and other materials reach teachers throughout the country. We have distributed over 2,000 hard copies of the curriculum, and many more have been downloaded from the Monarch Watch website.

The program is under formal evaluation to assess teacher and student improvement in science education, and preliminary feedback from participants is overwhelming. We are told that it is *inspiring* for students and teachers to witness monarch development, *empowering* to learn so much about a single topic that they feel that they are true experts, *challenging* to be involved with real research, and *involving*, particularly with regard to the conservation issues. The program rewards everyone involved—scientists, teachers, precollege students, and family and community members. Another positive outcome stems from the involvement of graduate students, who are future scientists and educators. Graduate students have been involved in a variety of capacities, from co-director of the project (L. Goehring), to designing the monitoring effort (Prysby & Oberhauser this volume), to sharing their research with workshop teachers (Goehring & Oberhauser this volume, Altizer et al. this volume). These students may approach scientific or other careers with a different attitude than those who have no involvement with pre-college educators and students, and can thus play important roles in shaping the changing focus of science education.

Financial support is key to the development of outreach programs, and our fund-raising strategy may provide a model for other ecology education programs. The pairing of scientists and teachers, in essence, the pairing of scientific experience with its delivery to the pre-college community, has been instrumental in attracting funders. The National Science Foundation provided initial funds for both Monarch Watch and Monarchs in the Classroom in a three-year grant from their instructional materials development program. We have received funds over multiple years from the Eisenhower Professional Development Program and the University of Minnesota Department of Continuing Education and Extension for summer workshops, and the Medtronic STAR Foundation for short workshops and the Monarch Fair. Finally, as the program has developed, product sales (larvae, curriculum and larval identification guides, slide sets, T-shirts and posters) and workshop fees provide an increasingly important source of support, and we expect one day may support the entire program.

Summary

The monarch butterfly is an ideal organism on which to center a program that promotes skills-based science education. With its rich and fascinating history of research and discovery, studying monarchs results in an increase in student understanding of basic scientific knowledge, develops scientist/teacher/student collaboration, and promotes awareness of environmental issues as well as the motivation to act on these issues. This entire Proceedings, and the North American Conference on the Monarch Butterfly attest to this. While the monarch is a unique and special example, any one of a myriad of organisms could form the basis of a pre-college program that does all of these things. There are incredible opportunities for scientist/educator partnerships in the changing face of pre-college science education.

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Monarch Watch: Education, conservation and research

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Abstract
Monarch Watch is a collaborative network of students, teachers, volunteers and researchers dedicated to the study of the monarch butterfly. Areas of emphasis include science education, conservation and research. The educational program consists of K-12 curricular materials (in collaboration with Dr. Karen Oberhauser, University of Minnesota), student-scientist collaborative projects and student research challenges. These materials are accessible through the Monarch Watch web site at: www.monarchwatch.org. Hard copy of the curricular materials is available and a 35-page Season Summary is provided each May to Monarch Watch members. Monarch Watch also maintains an electronic discussion list (Dplex-L), for those wishing to report on the migration and discuss monarch biology. Student-scientist research is underway on: monarch mark and recapture studies, orientation and navigation of migrants, use of isotopes to track monarchs, the size and mass of the migrant butterflies, and size of larval populations in the summer. Our conservation effort focuses on the importance of maintaining both summer and winter habitats for the monarch population. Butterfly gardening and habitat restoration is encouraged. Monarch Watch members represented 39 states, 3 Canadian provinces and 2,500 schools in the fall of 1997. In the 1997 season at least 76,000 monarchs were tagged by Monarch Watch participants and of these, 198 were recovered, including 49 at the overwintering sites in Mexico. Data and summaries from tagging and other projects are reported in the Season Summary, and posted to the web site.

Introduction
Monarch Watch is a collaborative network of students, teachers, volunteers and researchers dedicated to the study of the monarch butterfly. Areas of emphasis include science education, conservation and research. Our intent is to involve thousands of students and adults in a cooperative study of the biology of monarchs associated with the fall migration. The project is directed by Orley R. “Chip” Taylor (Professor, University of Kansas), Karen Oberhauser (University of Minnesota) and Brad Williamson (Olathe East High School, Kansas). Regional Monarch Watch coordinators throughout the eastern United States and Canada assist by recruiting and coordinating volunteers in their areas.

Monarch Watch was initiated as a research project in 1992; however, as the project developed, its educational potential became obvious. The charismatic nature of the monarch and its extraordinary migration captures the imagination of students. Students were thrilled to be involved in tagging and rearing monarchs and they became more confident while actively participating in “real” science. Teachers were extremely positive about the benefits of this program and many urged us to develop background and curricular materials for use in the classroom. From these responses it was clear that, because students were fascinated by monarch and their migration, this species provides us with an opportunity to introduce a wide variety of scientific concepts to the classroom. This “vision” of using monarchs to further scientific education led to the development of “Monarchs in the Classroom” (Oberhauser and Goehring, this volume) and provides much of the motivation for the development of our web site.

We also focus on monarch research and conservation of monarch habitats. The research projects are designed to not only enhance our knowledge of monarchs but to educate. By urging participation in collaborative scientific projects, students (and teachers) are introduced to the scientific process. We also challenge students to undertake independent scientific research. Although we promote monarch conservation, this is the weakest part of our program at this time. We are in the process of developing an extensive review of monarch conservation issues which, at the very least, will be posted to the web site. We are also in the process of developing a program, known as Adopt-A-Classroom, to provide educational materials for the primary schools within the monarch reserve in Mexico.

Education

The objectives of our educational program are threefold: to create curricular materials for use in the classroom; to engage students and the public in collaborative efforts to resolve questions of monarch biology; and to encourage independent research by students.

Curricular materials

"Monarchs in the Classroom", a K-12 science curriculum, has been developed by Karen Oberhauser and her graduate student staff (Stacey Halpern and Liz Goehring), working in collaboration with many Minnesota teachers (Oberhauser and Goehring, this volume). The curriculum is comprehensive and leads teachers and students through an inquiry-based study of monarchs. It has a strong interdisciplinary approach and lessons are congruent with K-12 concept and process standards as outlined in the National Academy of Science's National Science Education Standards. A hard copy version can be obtained by mail and electronic versions will soon be available both online and on the Monarch Watch CD-ROM.

Student-scientist projects

Student-scientist collaborative projects are a unique feature of our program. The monarch migration spans three countries and to study this phenomena we recruit volunteers and train them to obtain data that will help us answer specific questions about monarch populations and the migration. Five projects are underway and each will be described briefly below. A more complete explanation of each project can be found on our web site at: (www.monarchwatch.org/studproj/studproj.htm).

Tagging: Tracking the migration with mark and recapture methods

Many questions remain unanswered about the fall migration of the monarch population east of the Rocky Mountains. How do the monarchs move across the continent, i.e., do they move in specific directions or take certain pathways? How is the migration influenced by weather and are there differences in the migration from year to year? We need data to answer these questions. To obtain this information, we recruit volunteers located throughout the eastern range of the monarchs to participate in our tagging program, a large-scale mark and recapture effort. Because of the large size of the monarch populations, and the immense geographic area involved, the rate of recapture of the tagged migrating butterflies is low. Therefore, large numbers of tagged monarchs are needed to obtain sufficient recoveries and observations of the migration to answer our questions. This program has been very successful. Monarchs appeal to the students; they are fascinated by the concept of the migration and they enjoy having an excuse to collect butterflies. Teachers find that tagging is a good way to introduce students to science and students have the opportunity to contribute to a scientific study. In the fall of 1997, 76,000 monarchs were tagged by Monarch Watch members in 39 states and 3 Canadian provinces. The results of the tagging are summarized on the web site and in our Season Summary.

Isotopes: Tracking monarch migration with hydrogen isotopes

Local and long distance movements of animals have been tracked by biologists with a wide variety of marking systems. These methods require: 1) an initial capture of the animals; and 2) some form of recapture farther along the migratory route. Since only a small percentage of the initially marked animals are recaptured, the amount of data recovered with these techniques is limited. It would be ideal to skip the initial capture and marking step and still be able to obtain information on the origin and movement of any individuals captured along the migration route.

Recently, Keith Hobson and Len Wassenaar (pers. comm.) have developed a new and promising means of studying migratory species using a naturally occurring chemical signature, the ratio of the stable isotopes of hydrogen in hard tissues such as feathers or insect cuticle. The ratios of deuterium (H3) and more common hydrogen isotope (H2) in rainfall change in a distinct pattern across the continent. And, in theory, these same ratios are retained in the plant tissues from each area and in the organisms that consume these plants as well. Thus, it should be possible to use the hydrogen isotope ratios obtained from monarch wings to answer questions about the geographic origins of the butterflies from each of the roosting sites in Mexico. We may also be able to determine whether monarchs return to their region of origin during the spring migration.

During the summers of 1996 and 1997, we asked for volunteers from each state and province east of the Rockies to help with this study. There were over 160 applications to participate in this project, and, from these applicants, we selected 130 based primarily on location and experience. Each participant was sent a Monarch Rearing Kit containing eggs, instructions and data sheets. The protocol specified that the monarchs could only be reared on naturally occurring milkweeds whose only source of moisture was rainwater. The participants were asked to return three male and three female monarch adults, together with a dried sample of the milkweed used to rear the monarchs. Most of the volunteers successfully reared the monarchs, and 105 samples of milkweeds and monarchs from throughout the eastern monarch breeding area are now being analyzed for their hydrogen isotope ratios or “home signals.” Preliminary analysis of the data is promising and the first scientific papers based on these analyses should appear in 1998.

The educational value of this project has been outstanding, since it integrates information from a number of subject areas, such as meteorology, atmospheric physics, geography, physiology and ecology. The project has also brought students, teachers and parents together to contribute to a unique scientific study.

Flight vectors: Tracking the migration with snapshots of direction

The great monarch mystery is: How do inexperienced monarchs from Colorado to New England and the Canadian provinces all find the same traditional overwintering sites in Mexico each year? What environmental information is used by monarchs to guide their migratory flights? Do they use the sun as a compass? Are they guided by the earth’s magnetic field? Do they follow structural features of the landscape such as rivers and mountains? Do they use a combination of these, or perhaps some undiscovered method?

There are many ways to approach this problem but before we even attempt to answer the basic questions we need data on the directions taken by monarchs as they traverse the continent. Do the flight directions of monarchs change with latitude and longitude? This is a logical question. To reach the Mexican border between Del Rio and Eagle Pass, Texas, the major crossing area, monarchs from North Dakota should take a different, perhaps more southerly, route than those departing from Montreal. The latter would need to fly in a more southwesterly direction to reach the same region.

In this collaborative effort we ask participants to record two measures of flight: the vanishing bearings and the headings. Vanishing bearings are simply the compass heading of the butterfly as it disappears from view on the horizon. Vanishing bearings can be influenced by wind speed and direction but are valuable since they provide a measure of the net direction taken by the butterfly. Measures of headings are more valuable. In this case, the observer must be positioned directly behind the butterfly and be able to record the compass heading of the long axis of the body. This gives us the direction the butterfly is attempting to move even though its net direction might be different, due to the effects of wind. Records of vanishing bearings and headings obtained throughout the eastern region should tell us whether migrating monarchs change course in response to latitude and longitude. Once these data are assembled, we can ask whether the patterns of flight directions are random, all the same or correlated with other patterns such as the earth’s magnetic fields.

Size and mass: Measuring the effects of the migration on the monarch population

The monarch butterflies’ flight during the fall migration can be quite long, sometimes more than 2,500 miles (4,000 km), and hazardous. Many of the butterflies do not survive the journey. Some of the deaths are due to random causes but others may be due to the action of natural selection which favors individuals with specific characteristics. Little is known about which monarchs survive the journey and which do not. Is size and/or mass related to survival? Individuals representing all size and mass combinations may survive equally from their origin in the north to the roosts in Mexico, or perhaps individuals of particular size and mass groups are more apt to die along the way. If there is differential mortality, samples of monarchs obtained along the migration should reflect these differences in survivorship.

Data for this study are obtained by capturing monarchs and transporting them live to the classrooms, where they can be sorted by sex and then weighed and measured. Although the data are valuable, lessons learned by the students are equally important. In addition to learning how to capture, weigh, measure and release live specimens the students are asked to process and discuss the data. They are encouraged to focus on the significance of differences between the sexes in size and mass, the issues of selection, and how to compare their data with those obtained from other locations.

Larval monitoring: Assessing changes in monarch population numbers

To conserve a species, or a phenomenon such as the monarch migration, we need to learn as much as we can about the factors that determine year-to-year fluctuations in population numbers. Pollard transects and 4th of July butterfly counts, in which the numbers of adult monarchs seen along specific routes are systematically counted, give us snapshots of the population at specific times and places. Unfortunately, neither of these surveys is very predictive and they provide few insights or explanations for fluctuations in population size. However, monitoring the larval populations should provide the kind of detail needed to develop better predictions about the size of the migratory fall populations. The method developed by Michelle Prysby and Karen Oberhauser (this volume) is straightforward. Observers monitor milkweed patches periodically, searching for larvae and identifying them to instar. The number of larvae, and their stage, is given as a proportion of the total number of plants inspected. By following the procedures systematically each week and recording weather data, the condition of the plants, and predation of the larvae, the seasonal change in monarch numbers becomes clear. Comparing data from many locations with weather patterns should give us a better basis for predicting monarch population sizes.

Student research

Each year, we present challenges for students in the Season Summary and on the web site. The challenges are in the form of questions about monarch mysteries. The answers to these questions are unknown, but by making careful observations and/or designing appropriate experiments, students can obtain answers to these questions and further our knowledge of monarch biology. Our objective, by giving these suggestions and examples, is to encourage students to initiate their own research projects. Teachers have used these ideas for classroom discussions and a few students have used monarchs as the basis for Science Fair or independent study projects (Oberhauser and Goehring this volume). This approach of encouraging student research has not worked as well as we had hoped; it appears that both teachers and students need more guidance than we have provided. As a consequence, we (in collaboration with Karen Oberhauser, University of Minnesota) are exploring ways to develop the infrastructure for annual mini–Monarch Science Fairs at museums throughout the country. The results of these and other student projects will be posted to a student-scientist section on the web site.

Conservation

In the broad sense, the entire Monarch Watch/Monarchs in the Classroom program supports monarch conservation. To further the goals of monarch conservation, we are making an effort to educate the public as well as present and future decision makers; first, about the extraordinary biology of the monarch and secondly, about the threats to the continued existence of monarch populations. The long-term goal of this effort is to generate support for the continued maintenance of monarch habitats not only at the overwintering sites in Mexico but throughout North America. As a matter of policy, we support international efforts to protect monarchs through the establishment of monarch reserves and through habitat preservation and restoration. Due to financial limitations, our conservation activities are primarily educational. The health of the monarch populations is closely tied to the diversity and abundance of the 106 milkweed species in North America. Many of these species are rare and even endangered; therefore, we are making a strong effort to educate people about value of milkweeds. As part of this effort, we encourage propagation of milkweeds and butterfly gardening.

Research

In addition to the student-scientist collaborative research outlined above, we are attempting to answer many of the long standing questions concerning the basis for orientation and navigation of the monarchs on their migratory flights. Two of our studies, on sun compass orientation (Perez) and an analysis of recaptures of tagged monarchs (Rogg et al.) are summarized in this volume.

Studies are also underway on the patterns and dynamics of the migration. These studies are facilitated by reports from the extensive network of collaborators we have developed throughout eastern North America. From these reports we are also gleaning information on the physical and biological factors which influence the size of the monarch populations from year to year. Recently, in conjunction with our interest in population genetics, we have begun studies of the biology of the rare white form of the monarch known as nivosus.

Monarch Watch resources

To further our outreach program, we provide a variety of resources to our members and the public.

Web site

Monarch Watch is an electronically-based outreach program. Our principal means of providing educational materials is through our web site (www.monarchwatch.org). We communicate extensively with members and the public through an electronic discussion list (Dplex-L) and via e-mail. These means of communication, together with computer assisted answering machines and faxes, allow us to deal with a large number of members/clients each day and the response time is usually short.

The web site is extensive and continues to grow. Included on the site are background materials on the migration and biology of monarchs, the Monarchs in the Classroom curriculum, descriptions of the student-scientist collaborative projects, instructions on rearing monarchs, a photo guide to milkweeds, an extensive FAQ list, summaries of the results of tagging, a section on butterfly gardening, Dplex-L archives, lists of suppliers, extensive bibliographies and much more. The site is searchable; a user can key in a specific term, and come up with a list of all the locations within the web site files, including the bibliographies, in which this term is used. The searchability of the site adds to its value as a source of information and many students are using this feature to obtain the background material they need for original research and writing assignments.

Electronic discussion list (Dplex-L)

To facilitate communications about monarchs we maintain an electronic discussion list known as Dplex-L. Subscribers to the list are students, teachers, scientists and long-time monarch observers. The subscribers (N = 370) use the list to report observations about the spring and fall migrations and the state of the monarch populations. Other topics include how to use Monarchs in the classroom, rearing monarchs, news about monarchs, conservation issues, information about meetings and research. The list is relatively active, with about 2,500 messages per year. Compared to many similar lists, the quality and educational value of the messages are high and they provide a real-time representation of the migrations each year. Because of the educational and research value of these communications, the messages for each year are organized by subject and stored as an archive on the web site.

Season summary

Each spring we publish an annual Season Summary, which is distributed to members and supporters of Monarch Watch. This 35+ page report contains summaries of the tagging and recoveries from the previous fall and updates on other ongoing research projects. Readers are apprised of the state of the monarch populations for each season, based on our interpretations of the reports we have received from our many collaborators.

We use this forum to provide additional background on monarch biology for classroom discussion, to summarize news concerning monarch conservation, to suggest areas of study and to challenge students to initiate independent research.

Membership and use data

There are 1,800 members of Monarch Watch at the present time. Through our memberships, and by providing monarch educational materials, our program extends to approximately 2,500 schools and at least 100,000 students each year. The web site receives 100–300 visitors per day depending on the time of year and the electronic discussion list (Dplex-L) has 370 subscribers most of whom are teachers. Twenty-four hundred copies of the Season Summary are distributed to members and supporters of Monarch Watch each spring.

Future

Monarch Watch continues to grow. Each year our membership increases and we are able to improve the quality of the educational materials we provide through the web site and the Season Summary. Three new educational products will be available for 1998. The first is a series of posters suitable for use in classrooms and at nature centers. The posters illustrate the paths of the spring and fall migration, the overwintering areas in Mexico, the history of tagging, and the origins of tagged monarchs recovered in Mexico. The second product is a short video on monarch life history for K-4 students. This award-winning video is bundled with Gulliver's Story, an active-learning curriculum based on monarch biology. A CD-ROM containing all the information from the web site and the Monarchs in the Classroom curriculum will be available late in 1998. If we are able to secure additional funding, we will produce a curriculum for secondary school students, initiate additional student-scientist projects and sponsor student science fairs based on the monarch. All of these materials will be posted to the web site and we will produce updated CD-ROMs as appropriate. Eventually, the core information from the web site and the Monarchs in the Classroom curriculum will be online in Spanish and French as well as English.

Adopt-a-classroom

At Monarch Watch we have promoted conservation through education within the United States and Canada. As an organization, we are now mature enough to reach out to Mexico. Our plan, which we call "Adopt A Classroom," is to obtain instructional materials for the local schools.

The schools in the monarch reserve are simple cinder block buildings with high windows, many have poor lighting and some have no electricity. The classrooms are small and crowded, with crude and uncomfortable desks for the children. The teachers write lessons on worn-out blackboards. Basic textbooks are available, but workbooks, writing materials and even paper are scarce. Library resources and supplemental teaching aids, which have proven to be so effective in teaching the concepts of math and science, are almost totally lacking in these schools. Working with innovative teachers, we have designed a basic math and science kit which contains instructional materials appropriate for the classrooms in Mexico. The math and science kits cost $100 each and we are seeking funds to purchase the materials for these kits.

Groups can ADOPT-A-CLASSROOM for $100. We will purchase the materials, assemble the kits and deliver them in the name of the group, or in the names of multiple contributors, to the schools and classrooms in Michoacán. We will also assemble and in some cases purchase, classroom supplies, Spanish language story books, and reference materials for these schools. We are also asking individuals and schools to contribute used slide viewers, overhead projectors, and percussion instruments such as drums and tambourines. Once we have a full van-load of instructional materials, we will deliver them to the schools in Michoacán.

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Urquhart Butterfly Garden

by ***Donald A. Davis***
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The Urquhart Butterfly Garden is Canada's first Municipal Butterfly Garden. It is the fulfillment of the dream of one individual, who was able to draw together the necessary financial, material and human resources, create the necessary partnerships and persuade the Council of the Town of Dundas that this was a worthy project. Besides providing habitat for butterflies, the Garden serves many other useful functions, such as providing students with opportunities for environmental studies.

A number of years ago, I attended the annual General Meeting of the Federation of Ontario Naturalists in Hamilton, Ontario, Canada. At that time, guest speaker Monte Hummel, President of the World Wildlife Fund (Canada) stressed the importance of small-scale environmental projects. One such project is The Urquhart Butterfly Garden, named after Frederick and Norah Urquhart, internationally renowned pioneers in the field of insect migration research.

The Urquhart Butterfly Garden is located in Centennial Park in the Town of Dundas, Ontario. Dundas is located at the western end of Lake Ontario and on the edge of an ecological zone called Carolinian Canada. This zone contains flora and fauna species more often associated with more southern climates. One fine day in September 1991, a giant swallowtail butterfly deposited a tiny egg on a rue plant in the front garden of Chapman's Bookstore in downtown Dundas, Ontario. This rare butterfly and her single egg provided the impetus for founder Joanna Chapman to begin planning for Canada's first municipal butterfly garden.

The creation of the Garden is a remarkable achievement and testament to the determination and dedication of Joanna Chapman. In 1992, Chapman formed a steering committee called The Butterfly Coalition, to raise funds, obtain the necessary approvals and ensure that the butterfly garden would be designed and constructed. Members of this committee included members of local environmental and cultural groups, including the Hamilton Field Naturalists, Dundas Rotary, Dundas Heritage Society and the Garden Club of Dundas. The municipal authorities of the town of Dundas were not at all convinced that this project was worthy of consideration or could be completed. Some were openly critical of the project and refused to support it.

In spite of this derision, Chapman and the Butterfly Coalition forged ahead. After successfully negotiating and signing a complicated agreement with the Town of Dundas, Chapman and her committee began raising funds and constructing the Garden in the spring of 1994.

The Garden consists of six beds, surrounded by a maze of walkways. There are also three natural areas in the 1.2 hectare garden. The Garden is situated at the east end of Centennial Park and at the terminus of the historic Desjardins Canal. The Garden was constructed on top of what was originally the turning basin of the canal—now long filled in with construction rubble. The Garden is in immediate proximity to the City of Hamilton, the Royal Botanical Gardens and McMaster University. The Garden receives an abundant amount of sunlight during the day and has a generous water supply nearby.

The Garden was constructed in stages as funding, supplies and volunteers became available. Some services, such as those of a construction company, had to be purchased. Major funding was provided by Environment Canada - Environmental Partners Fund, as well as foundations, non-profit groups, corporations and individuals, including Joanna Chapman and the Urquharts. From 1992 to 1997, $65,000 Canadian was raised. Further donations to the Garden included a wide range of materials and services, again a testament to Chapman's creative talent and resourcefulness. Donations included plant labels, the original layout strategy, straw and manure, a tool shed, hoses, artwork and a host plant manual.

The beds, each about 20 metres by 10 metres, consist of nectaring and host plants in raised perennial beds. While some plant stock was obtained from local sources, many local garden centres, nurseries and greenhouses willingly donated plant material. In order to create new beds, plants were later subdivided in the older beds and some annuals were planted to fill in bare spaces and improve the appearance of the Garden.

The Garden makes liberal use of compost and manure and is pesticide-free. Centennial Park is a long rectangular park and there is sufficient room to expand the Garden in the future.

Chapman and her Committee encountered many challenges and setbacks. For example, shortly after the bank of the canal was planted with perennials, a flock of Canada geese arrived and ate them. It was discovered that by allowing tall grass and vegetation to grow along the bank, and also encouraging the nearby Royal Botanical Gardens to not mow their banks, the geese were deterred from approaching the Garden.

Many species of nectar plants—shrubs, perennials and annuals of varying heights that bloom in various seasons—have been planted in the Garden. These are listed in Table 1. The Garden also contains host plants used by at least 21 common butterfly species (Table 2).

Table 1 **Plants of the Urquhart Butterfly Garden**

Plant name	Taxonomic name	Longevity-type
Beebalm	*Monarda sp*	perennial
Black-Eyed Susan	*Rudbeckia sp*	perennial
Blazing Star/Gayfeather	*Liatris sp*	perennial
Butterfly Bush	*Buddleia sp*	perennial shrub
Butterfly Weed	*Asclepias tuberosa*	perennial
Cosmos		annual
Daisy: Ox-Eye, Shasta	*Leucanthemum sp*	perennial
Fall Aster, New England Aster	*Aster novae - angliae*	perennial
Globe Thistle	*Echinops sp*	perennial
Goldenrod	*Solidago*	perennial
Joe-Pye Weed	*Eupatorium purpureum*	perennial
Lantana		annual
Lavender	*Lavandula sp*	perennial herb
Marigold	*Tagetes sp*	annual
Phlox	*Phlox paniculata*	perennial
Purple Coneflower	*Echinacea purpurea*	perennial
Sage	*Salvia officinalis*	perennial herb
Sneezeweed	*Helenium autumnale*	perennial
Spearmint	*Mentha spicata*	perennial herb
Stonecrop	*Sedum sp*	perennial
Thyme	*Thymus sp*	perennial herb

Table 2	Butterflies and host plant
Butterfly name	**Caterpillar host plant**
American Copper	Sheep sorrel, curly dock
American Painted Lady	Everlasting, daisies, asters
Cabbage White	Cabbage family, nasturtiums
Comma	Nettles, hops, elms
Common Sulphur	Legumes, alfafa, clover
Coral Hairstreak	Plums, wild cherries
E. Black Swallowtail	Fennel, dill, parsley, rue
European Skipper	Timothy (grass)
Gray Hairstreak	Oak, corn, legumes
Little Wood Satyr	Various grasses
Meadow Fritillary	Violets
Monarch	Milkweed
Mourning Cloak	Willow, elm, hackberry
Painted Lady	Thistle, mallow, daisies, asters
Pearly Crescentspot	Asters
Question Mark	Nettles, hops, elms, hackberries
Red Admiral	Nettles
Red Spotted Purple	Willow, poplar, hawthorn, apples
Tiger Swallowtail	Willow, ash, cherries
Viceroy	Willow, apple, cherries
Wood Nymph	Various grasses

It should be noted that the Province of Ontario retains a longstanding piece of legislation entitled The Weed Control Act, originally designed to protect Ontario's agricultural industry by listing wild plant species thought to be of hindrance to agricultural crops. A number of host plants found in the Urquhart Butterfly Garden are designated as "noxious weeds", including milkweeds, wild carrot and thistles. Theoretically, a weed inspector could order that these plants be destroyed. Certainly a review of this Act and the schedule of noxious weeds is long overdue.

The Garden is maintained by a group of volunteers, who meet every week during the growing season. Natural growth is permitted, with selective removal of certain unwanted species, such as ragweed. As the beds have matured, vegetation has grown between and over the limestone slab border.

Another noteworthy feature of the Garden is the Information Kiosk. Again, Chapman solicited volunteer help in its creation. Research assistance and preliminary layout were completed by Professor Bob Henderson and students from the Department of Environmental Studies at McMaster University. Nature photographs were donated by local photographers. The Kiosk is three-sided and provides extensive information on the construction of the Garden, sources of funding, the life history of the monarch butterfly and the work of the Urquharts, local butterfly species and organic gardening.

The Garden was officially opened on Saturday, July 26. 1997, which coincided with the 150th anniversary of the Town of Dundas. The current mayor and many councilors were in attendance to praise Joanna Chapman and the volunteers for their accomplishments. I had the privilege of representing Dr. and Mrs. Urquhart at the opening ceremony and assisted with the unveiling of the Information Kiosk.

While the original steering committee has been disbanded, Chapman and members of the Butterfly Coalition regularly visit schools to share their knowledge of butterflies and organic gardening. In 1998, Joanna hopes to raise $1,500 for tools and plants. Chapman is also making arrangements through the Hamilton Foundation for funds to be allocated for the perpetual care and maintenance of the Garden when she is no longer able to carry out the management of the Garden herself.

The Urquhart Butterfly Garden has many useful roles to play. There are obvious benefits for the local butterfly population. Many butterfly species are now rare or endangered, and there are fewer numbers of once-common butterflies. This decline is mainly because of loss of habitat and because of the indiscriminate use of herbicides and pesticides. Chapman and members of the Butterfly Coalition strongly advocate for environmentally-friendly garden and agricultural practices, and like the Urquharts, advocate for the generous use of compost and manure and a reduction in the use of herbicides and pesticides.

The Garden is an important education resource for both school children and adults. Chapman notes that long before the flowering plants are in bloom and butterflies are seen in the Garden, scores of visitors come in the early spring to look for the first sprouts emerging from the soil. There are numerous opportunities throughout the year to learn about the life histories and identification of flora and fauna. As the Garden is strategically situated in a sheltered valley, not far from the famous Cootes Paradise Nature Sanctuary, it is possible that the Garden is situated in or near a wildlife corridor. Ducks, geese, swans, herons and other birds and wildlife are frequently seen in swimming and feeding in the canal.

The Urquhart Butterfly Garden is a place of peace and beauty, and was designed to afford opportunities for solitude and reflection. Visitors should come away with a better understanding and appreciation of the living things and the environment as a result of their experiences in the Garden. A number of visitors have indicated their intention of exploring the possibility of creating a similar garden in their town or city.

For further information, contact Joanna Chapman, Coordinator, Butterfly Coalition, 11 Cross St., Dundas, Ontario L9H 2R3.

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Participación comunitaria: un proceso a largo plazo de manejo y provechamiento de recursos naturales

por *Ana María Muñiz Salcedo, Guadalupe del Río Pesado, Gabriel Sánchez Ledezma*
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Todos los aquí presentes hemos sido testigos de una u otra forma del daño que han sufrido los recursos naturales de la región de la reserva de la mariposa monarca. Y de cómo la situación socioeconómica de sus pobladores se ha ido deteriorando día con día.

¿Cuál, o mejor dicho, cuáles son las razones por las que las áreas de invernación de la mariposa monarca en nuestro país se encuentran inmersas en esta profunda y compleja problemática ambiental y social?

Creemos que, en principio, esto obedece a los conflictos y limitantes derivados de la falta de un desarrollo socioeconómico regional y a la forma en la que se han llevado a cabo los programas de conservación del recurso forestal, que han contribuido a extremar las condiciones de marginalidad de los ejidos y comunidades indígenas, a ahondar la pobreza de la gente de la región y a acrecentar la destrucción de sus recursos silvestres.

Hoy en día existe un consenso general con respecto a que el desarrollo sustentable es la opción más viable para resolver estos problemas. Esto es, un tipo de desarrollo que favorece la conservación de los recursos naturales en una búsqueda del mejoramiento de la calidad de vida actual de las personas sin comprometer esa posibilidad en el futuro.

Este tipo de desarrollo requiere que las comunidades rurales y urbanas se interesen en el uso y manejo sustentable de los recursos naturales de su localidad o región y participen en un proceso de trabajo comunitario que estimule la creación de una conciencia ambiental de grupo. Se necesita, entonces, un cambio de actitud de las personas hacia los recursos naturales.

¿Cómo lograr este cambio de actitud? A través del trabajo comunitario y una labor de promoción que no parta de la imposición, sino de que la comunidad, en un proceso de análisis y reflexión, descubra y construya una nueva forma de vida.

La tarea de iniciar y dirigir el trabajo comunitario requiere de un promotor, una persona crítica, activa, pero sobre todo honesta y comprometida, que a partir de las condiciones y necesidades de la comunidad proporcione apoyo a la gente para que resuelva mejor sus problemas y planifique con acierto sus proyectos.

Una ayuda auténtica es aquella en cuya práctica todas las partes comprometidas se apoyan entre sí, crecen juntas en un esfuerzo común por conocer la realidad y se esfuerzan en transformarla. De ahí que un promotor interesado en resolver la problemática ambiental de su localidad de origen tenga entonces una mayor disposición para colaborar en la solución de los problemas y necesidades comunitarios, y así asumir un papel de servicio y compromiso con su gente.

Tratar de reducir el grave deterioro en el que se encuentran los recursos naturales de la Reserva Especial de la Biosfera Mariposa Monarca, creemos que es un reto en el que necesariamente debe estar involucrada la población de la región, y que precisa la preparación de promotores con características como las aquí descritas.

¿Cómo lograr este propósito? A través de cursos de participación comunitaria que permitan al promotor desarrollar en sus labores cotidianas habilidades para planear, capacitar, motivar y organizar a sus comunidades en torno de actividades de conservación de los recursos naturales; modificar o adoptar prácticas productivas que funcionen dentro de los límites de la capacidad de los ecosistemas presentes en el área, así como defender el patrimonio natural de la región.

Con esta idea en mente, en 1995 varias organizaciones no gubernamentales (el Consejo Nacional de la Fauna, AC, el Centro Campesino para el Desarrollo Sustentable, AC, Guardianes de la Monarca, AC, Biosfera Terrestre, AC) e instituciones de gobierno y de educación superior (el Instituto Nacional de

Ecología, el Instituto Nacional Indigenista y el Instituto Politécnico Nacional), con el apoyo financiero del Departamento de Vida Silvestre y Pesca de Estados Unidos, iniciaron un proceso de educación ambiental con algunas comunidades del área de la reserva.

En noviembre de ese año, en la ciudad de Pátzcuaro, el Comité constituido por esos organismos gubernamentales y no gubernamentales organizó un encuentro de campesinos: el I Curso-Taller para Promotores Ambientales Campesinos de la Reserva Especial de la Biosfera Mariposa Monarca.

Este encuentro tuvo como propósito reunir a personas de 24 comunidades de la región para que realizaran un ejercicio de análisis y reflexión sobre la problemática económica, ambiental y social en la que vivían. Esta práctica llevó a las 52 personas asistentes a concebir el lugar en el que les gustaría vivir y a elaborar un plan de acciones que respondía a las necesidades locales y fomentaba el trabajo colectivo, la autoestima, la confianza y el optimismo.

Los campesinos se pronunciaron en esa ocasión por conseguir una Reserva Especial de la Biosfera Mariposa Monarca organizada, funcional, productiva y con bosques sanos para una mejor calidad de vida. Condición ideal a la que el colectivo llegó después de haber analizado los problemas.

Los principales aspectos que los asistentes al curso-taller discutieron se pueden resumir de la siguiente manera:

A. Principales problemas detectados:
   - Erosión
   - Baja producción agrícola
   - Deforestación
   - Deterioro de bosques.
B. Principales obstáculos:
   - Falta de organización de la comunidad
   - Inadecuada respuesta gubernamental
   - Falta de una adecuada capacitación
C. Planeación de acciones:
   - Revisar el decreto de creación de la reserva, decisión consecuente con la inquietud manifestada durante todo el proceso del curso-taller. Elaboraron una carta dirigida a la secretaria de Medio Ambiente, Recursos Naturales y Pesca, Julia Carabias Lillo, en la que le pedían la revisión del decreto. A esta carta la acompañan: a) una propuesta de conservación; b) una propuesta de restauración, y c) una propuesta de aprovechamiento de recursos naturales;
   - Elaborar reglamentos internos para las comunidades y exigir su cumplimiento
   - Formar cooperativas
   - Identificar necesidades de asesoría y capacitación específicas para resolver problemas como la erosión, la baja producción agrícola y el ecoturismo, entre otras.

Los campesinos se comprometieron a informar a las asambleas comunitarias sobre todo lo que sucedió en el curso-taller, así como someter a su consideración la carta para la revisión del decreto y los documentos que lo acompañan para votar su aprobación.

Pocas veces se menciona el contexto social en el proceso de la comunicación, pero debe tenerse en cuenta que influye determinantemente en éste, pues propicia que la comunicación sea más fácil o difícil, que haya comunidad de intereses u oposición, que se interprete adecuadamente o se desvirtúe un mensaje y que haya una mayor o menor retroalimentación. Es así como un campesino escucha y entiende mejor a otro campesino. Por esta razón la metodología aplicada es dirigida por un grupo de campesinos especializados en tareas de trabajo comunitario.

Un componente importante de apoyo al curso-taller fue brindar a los asistentes la oportunidad de conocer los esfuerzos y experiencias que otras comunidades campesinas de México realizan en pro de la conservación de los recursos y del desarrollo de la participación comunitaria, así como la práctica de actividades productivas sustentables.

Para los campesinos, algunos de los elementos de interés de estas presentaciones fueron: el porqué y para qué (objetivo) del tipo de actividad productiva que llevan a cabo, la metodología de participación utilizada por las comunidades, la manera en que las comunidades se organizan para desarrollar el trabajo, sus logros y dificultades, así como la forma en que han sido superadas estas últimas. A este respecto, los asistentes comentaron que esta experiencia fue muy importante e ilustrativa, ya que les permitió visualizar la posibilidad de llevar a cabo esas actividades al tiempo que les dio otras alternativas de trabajo.

El comité organizador acordó como mecanismo de seguimiento del proceso de educación ambiental el que los asistentes al curso-taller motivaran en sus comunidades el desarrollo de diversas propuestas de trabajo para llevar a cabo el plan de acciones. Ésta sería una de sus primeras tareas como promotores.

Una vez que las comunidades concluyeran las propuestas, la institución encargada de recogerlas sería el Instituto Nacional de Ecología, a través del personal técnico y administrativo de la reserva, ya que es el órgano que el marco jurídico de México designa como el responsable de dar seguimiento a todas las acciones que se llevan a cabo dentro de la reserva. El apoyo técnico y financiero tendría que pasar por una solicitud a personas, organizaciones o instituciones de amplia experiencia en los proyectos a desarrollar.

El curso-taller impulsó a los asistentes a analizar y reflexionar sobre la situación ambiental, social, cultural y económica de sus comunidades y el papel que ellos tendrían que desempeñar para llevar a cabo un cambio. Esto se reflejó en el desarrollo de las estrategias y acciones que demuestran que la gente dedujo su problemática percatándose de que la iniciativa para mejorar su comunidad tendrá que ser propia y no de personas ajenas a ésta.

Durante mayo de 1997 Alternare invitó a los comisariados de 24 comunidades del área para llevar a cabo un segundo encuentro de campesinos cuyo objetivo fue seguir motivando la participación comunitaria. Esta reunión se llevó a cabo en junio de 1997 en la ciudad de Pátzcuaro, Michoacán. En esta ocasión asistieron 48 campesinos provenientes de 19 comunidades indígenas y ejidos. Para el desarrollo de este segundo taller se utilizó la misma metodología participativa que en el anterior. Es importante señalar que los problemas y los obstáculos mencionados por los campesinos coinciden en general con los referidos en el encuentro de 1995.

En esta ocasión, la planeación de acciones se definió en varias etapas:

En la primera etapa se convocó a las asambleas de sus comunidades para informar acerca de lo acontecido en el encuentro y definir si la comunidad estaba interesada en emprender el plan de acción propuesto, así como la forma de participación de la comunidad. Con estas actividades se intenta motivar la organización y el trabajo comunitario.

Después de las discusiones dentro de las comunidades, los asistentes se comprometieron a acudir a la reunión del 27 de septiembre en Angangueo, Michoacán, para informar del interés de aquéllas en participar en este esfuerzo y llevar la propuesta específica de la actividad o actividades con la que les interesa iniciar este trabajo conjunto.

A esta reunión asistieron representantes de ocho poblaciones, de las cuales las comunidades indígenas Francisco Serrato, Donaciano Ojeda y Nicolás Romero, así como la comunidad San Felipe de Jesús solicitaron capacitación en dos áreas: conservación de suelo y agua y manejo de bosques.

Finalmente, el ejido Jesús de Nazareno solicitó apoyo para denunciar la contaminación de las aguas del río; y el ejido El Paso manifestó interés en contar con material videográfico sobre diversos temas.

Según el plan de acciones propuesto, durante octubre Alternare y las comunidades interesadas trabajaron juntos en la realización de los cuatro cursos de conservación de suelo y agua planeados. Estos cursos, a los cuales asistió un promedio de 15 personas, fueron un esfuerzo mutuo en el que la comunidad proporcionó durante cincos días la comida y la vivienda, y el instructor, la capacitación.

Después de analizar las reflexiones de los campesinos, es evidente que pretender resolver la problemática ambiental de la reserva sin atender la organización de la comunidad, la capacitación y la ineficiente respuesta gubernamental derivará, sin temor a equivocarnos, en programas sin respuesta efectiva en las localidades y sin ningún impacto para la conservación de los recursos naturales de la región.

Los resultados obtenidos a lo largo de este proceso no son nuevos. Sin embargo, nuestra propuesta de que son los habitantes de la región los que deben reconocer la necesidad de un cambio de actitud con la ayuda y el apoyo de promotores locales formados en su trabajo diario, para que de esta forma sean las comunidades las que planeen y desarrollen programas propios, redundará en su mejor calidad de vida y en la conservación de sus recursos naturales.

Por último, pero no menos importante, creemos que para desarrollar con éxito este tipo de proyectos a largo plazo, es necesario reconocer que se requiere la conjunción de esfuerzos, advirtiendo las capacidades y limitantes de todas las partes, de tal forma que la organización, institución o personas que se involucren en el proyecto tendrán oportunidad de actuar en forma idónea sin distraerse en actividades que no son las importantes o para las cuales no están capacitadas.

Educación ambiental: herramienta para la conservación

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Reiteradamente se asume la educación como un fin y no como una herramienta para alcanzar objetivos. En el caso de la conservación de los recursos naturales, esto es especialmente cierto; se proponen toda una gama de contenidos y un sinnúmero de materiales para el desarrollo del proceso educativo, todos enfocados a destacar la importancia de conservar a tal o cual especie o hábitat, desafortunadamente, en el diseño y aplicación de los mismos (para el mayor número de los casos), sin contextualizar y definir las condiciones económicas y sociopolíticas de fondo que genera la problemática que queremos combatir en favor de una especie o entorno determinados.

Los procesos de educación ambiental, desde nuestra perspectiva, deben dar respuestas a preguntas como la siguiente: ¿de qué manera definir nuevas estrategias hacia un desarrollo justo socialmente, equitativo económicamente y respetuoso de los ciclos naturales y la cultura locales?

El presente trabajo tiene como propósito fundamental analizar el papel de la educación ambiental como herramienta para el desarrollo sustentable.

Antecedentes necesarios

Es un hecho conocido y ampliamente documentado que las presiones de la sociedad sobre la naturaleza están sobrepasando su capacidad de autorregulación y renovación, debido sobre todo a que no se considera un aspecto básico: las características concretas del sistema natural en donde se desarrollan las actividades productivas. Pareciera, a primera vista, que con el solo conocimiento de las características ecológicas de los sistemas naturales sobre los cuales se ejerce la actividad productiva y la actuación en el desarrollo de ésta, de manera que se respeten los ritmos y capacidades de regeneración y amortiguamiento de los ecosistemas, bastaría para que se pudiera alcanzar una forma de aprovechamiento de la naturaleza que lograra la conservación en condiciones tales que permitiera continuar sirviéndose de ella como base material para el proceso productivo. No obstante, la articulación con el sistema social que emprende la utilización y aprovechamiento de la naturaleza no tiene como racionalidad fundamental el cuidado y protección del medio ambiente. Es necesario encontrar una racionalidad diferente a la que propone actualmente el modelo de desarrollo imperante para la utilización de la naturaleza.

Se ha planteado y promovido intensamente la necesidad de generar una conciencia ecológica que permita transformar las relaciones del hombre con la naturaleza, pero esta generación de conciencia ecológica no se reduce a la toma de conciencia personal sobre las propias responsabilidades en el cuidado y protección del medio ambiente, sino al cuestionamiento de las verdaderas causas del deterioro ambiental, que se encuentran justamente en los estilos de desarrollo seguidos hasta la fecha. De poco sirve que las personas cobren conciencia de los daños que produce al medio ambiente su actividad diaria como consumidores de ciertos productos si la oferta de éstos es la única en el mercado, si para satisfacer sus necesidades básicas cotidianas no se tienen a la mano formas alternativas de aprovechamiento de la naturaleza que consideren los impactos ambientales.

En la Primera Conferencia Intergubernamental sobre Educación Ambiental celebrada en 1977 en Tbilisi, en la hoy desaparecida Unión Soviética, convocada por PNUMA-Unesco, el principio número uno estableció:

1. Aunque es obvio que los aspectos biológicos y físicos constituyen la base natural del medio humano, las dimensiones sociocultural y económica y los valores éticos definen por su parte las orientaciones y los instrumentos con que el hombre podrá comprender y utilizar mejor los recursos de la naturaleza para satisfacer sus necesidades.

2. La educación ambiental será resultado de una reorientación y articulación de las diversas disciplinas y experiencias educativas que faciliten la percepción integrada del medio ambiente, haciendo posible una acción más racional y capaz de responder a las necesidades sociales.
3. Un objetivo fundamental de la educación ambiental es lograr que las personas y las colectividades comprendan la naturaleza compleja del medio natural y del creado por el hombre, resultante de la interacción de sus aspectos biológicos, físicos, sociales, económicos y culturales, y adquieran los conocimientos, valores, comportamientos y habilidades prácticas para participar responsable y eficazmente en la prevención y la solución de los problemas ambientales y en la gestión de la cuestión de la calidad del medio ambiente.
4. Propósito fundamental de la educación ambiental es también mostrar con toda claridad las interdependencias económicas, políticas y ecológicas del mundo moderno, en las que las decisiones y comportamientos de los diversos países pueden tener consecuencias de alcance internacional. (Unesco, 1980)

La Conferencia de Tbilisi le da a la educación ambiental un sentido totalmente diferente del que hasta ese momento se le había otorgado, ya que pone de manifiesto el conjunto de mediaciones que caracterizan este campo, evitando con esto que se le reduzca únicamente a lo ecológico. Destaca también el carácter histórico de los problemas al señalarlos como el producto de la historia de la relación entre hombre y naturaleza, con énfasis en las determinaciones económico-ecológicas y situando los problemas ambientales en un orden global. Lo anterior le da a la educación ambiental una connotación totalmente diferente a la que ha privado, más vinculada a los aspectos técnico-ecológicos y a la propuesta conservacionista que, asépticamente, en la mayoría de los casos descarta los aspectos económicos, políticos y sociales de su análisis, reduciéndolos desafortunadamente a posiciones simplistas. O aun considerándolos, destacan en su interpretación como una “mala” relación entre la sociedad y la naturaleza procurando ignorar como un elemento de deterioro ecológico las injustas relaciones sociales prevalecientes, o aun considerándolas no hacen sino matizar su importancia. Esto es contradictorio, pues es allí en donde reside a nuestro juicio el quehacer más importante de la educación ambiental, cuando incorpora en su análisis las relaciones del ser humano no sólo con la naturaleza, sino consigo mismo y con otros humanos, cuestionando entonces las injustas estructuras sociales y señalando posibles caminos para acercarse a un proceso de desarrollo sustancialmente diferente, con la participación protagónica de todos los sujetos sociales en la construcción de sociedades justas y ambientalmente sustentables.

Sustentabilidad y educación ambiental

Las discusiones en torno del desarrollo sustentable no están hoy ni con mucho acabadas; por el contrario, se han extendido a muy diversos ámbitos, pero lo que sí podemos aceptar es que éste es un concepto y proceso en construcción que busca marcar rutas hacia un modelo de racionalidad que ponga el énfasis en la satisfacción de las necesidades esenciales de los que menos tienen y moderar las necesidades superfluas de los que más consumen, todo sin comprometer la posibilidad de reproducción de los ciclos naturales.

El problema no es sencillo, ya que involucra toda una serie de cambios fundamentales en las formas de concebir el desarrollo. Se requieren transformaciones conceptuales, metodológicas y de valores para avanzar hacia el desarrollo sustentable. Es especialmente necesario tener formas democráticas en el ejercicio del poder y garantizar posibilidades reales de participación social. En este complicado, diverso e intrincado proceso, la educación surge como una herramienta fundamental.

Entendemos la educación ambiental como un proceso de aprendizaje permanente en el que se respetan todas las formas de vida como un derecho de todos; que tiene el propósito de formar ciudadanos con conciencia local y planetaria que respeten la autodeterminación de los pueblos y la soberanía de las naciones; no reconocemos como neutra a la educación ambiental, sino basada en valores específicos y como un acto para la transformación social.

Como afirma Guillén, la educación ambiental escolarizada (que vale para la educación no formal) no puede ni debe ser concebida como una nueva disciplina que segregue el conocimiento y lo compartimentalice; diversos autores han discutido sobre la idea de considerar la educación ambiental como un eje que permita unir los conocimientos de las múltiples disciplinas. “El reto es complejo, ya que más allá de su bondad discursiva un sistema transversal de enseñanza debe luchar con inercias disciplinarias que se resisten a la integración. Por otro lado, resulta claro que el ejercicio no puede consistir en tomar fragmentos de cada disciplina e integrarlos forzadamente y que la organización del tiempo escolar no contempla la incorporación de esta dimensión y en consecuencia no existe un espacio formal para llevar a cabo actividades de educación ambiental" (Guillén, 1997).

Otro asunto fundamental es que los niveles de intervención, en lo formal como en lo no formal, son muy diversos. Pero todos estos niveles encuentran su problema más importante en la percepción de que el problema ambiental es en realidad un asunto ecológico que puede resolverse entonces educando en este solo eje (el ecológico), lo que sobresimplifica la propuesta.

La diversidad de los esfuerzos en las modalidades de educación ambiental que impulsan las llamadas organizaciones no gubernamentales es muy amplia y escapa a las posibilidades de este documento; no obstante, es esta modalidad el espacio "natural" de estos organismos por las características de su surgimiento y por el hecho de que el campo de las instituciones públicas está vedado para ellos. Sus acciones van desde la generación de folletos y artículos periodísticos hasta la realización de mítines y protestas o el trabajo con sistematicidad en algunas comunidades.

Los grupos no gubernamentales desarrollan acciones educativas de carácter general. En muchos casos no hay una definición precisa de sus destinatarios, una metodología de trabajo adecuadamente estructurada y una evaluación de los avances. El problema del seguimiento y la evaluación de los proyectos educativos es uno de los principales obstáculos a los que se enfrenta el quehacer educativo de estos grupos. Pocos saben realmente cuáles son los resultados concretos de su trabajo en cuanto a la modificación de las pautas de conducta, la conservación de los recursos naturales o el mejoramiento de las condiciones de vida de la población a la que dirigen sus esfuerzos.

La mayor parte de estos grupos no efectúa investigación en el campo de la educación ambiental, y la mayoría de las investigaciones de las que hacen uso proviene de especialistas que carecen de una práctica educativa en este campo. Abordan su trabajo desde una perspectiva pedagógica y dejan de lado los indicadores relacionados con la transformación del comportamiento social o del entorno, que en última instancia son los objetivos de fondo de la educación ambiental.

La mayor parte de los grupos tienen en su discurso la necesidad de realizar una labor educativa participativa en las comunidades en donde llevan a cabo sus proyectos, pero esto no se ve reflejado en el planteamiento de los mismos y mucho menos en su actividad. Como afirma Salvador Morelos (1992), en este sentido, "los educadores ambientales tenemos mucho que aprender de los grupos que trabajan en el campo del desarrollo social".

Respecto de lo antes dicho, parece que a quienes nos desenvolvemos en el campo de la educación ambiental nos está sucediendo lo que César Carrizales Retamoza critica en lo que denomina los conceptos estelares en la formación:

"Llamo conceptos estelares o superconceptos a aquellos que residen en el deber ser, que simulan orientar al cómo y que, con frecuencia, desde ellos se juzga lo realizado. A los conceptos estelares los encontramos en los discursos de la formación, sean: políticas educativas, curriculares, ensayos de especialistas, y en las experiencias docentes. Seguramente ya saben a cuáles conceptos me refiero, la lista es larga, señalaré algunos de ellos. Es común señalar que debemos formar estudiantes, docentes, investigadores y profesionistas: *críticos, originales, integrales, creativos, comprometidos, transformadores* y que respondan a las *necesidades sociales*".

Coincido plenamente con Carrizales y considero que a la educación ambiental para la conservación le pasa exactamente lo mismo que a los discursos de la formación educativa; estamos encerrados en realizar procesos de educación ambiental que parten más de la declaración y de consensos vagos, en el deber ser, y sumamente preocupados por iniciar los procesos educativos y llegar a la acción sin cuestionarnos para qué hacemos educación ambiental, a quiénes dirigimos nuestra acción y sobre todo en qué contexto socioeconómico, político y cultural estamos realizando nuestra acción educativa.

Education beyond boundaries—the monarch butterfly

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Abstract

The student exchange is a program initiated by the Canadian Museum of Nature (CMN) and *la Fundación Mexicana para la Educación Ambiental A.C.* (FUNDEA). It resulted from discussions during the first conference on the Conservation of Biodiversity and Biological Resources in North America (March 1994). In an effort to protect the hundreds of thousands of monarch butterflies that fly from Canada to Mexico in the fall, Canada and Mexico reached an agreement in October 1995, to give special attention to the butterfly's winter and summer homes. The CMN is one of the key players in the initiation of this accord with its Travelling exhibit " Butterfly beyond boundaries" and the Canada-Student Exchange programme.

The objective is to promote scientific and cultural exchange between Canada and Mexico by means of a school project carried out by high school students from both countries. The project will be an exchange of experiences between participants, and will inform future leaders and decision-makers about conservation and protection problems of the environment.

Introduction

For many Canadians and Americans, monarchs are a sign of summer. Gracefully, they fly about the flowers in the meadows of southern Canada and northern United States. But come fall, people in Mexico and California get to know monarchs in a different way. There, monarchs gather by the millions, painting the trees bright orange.

Whether we delight in the monarch's solitary, carefree nature, or its gregarious show of colour, we all share a special fondness for the monarch butterfly. But with this pleasure comes the responsibility for protection.

The Canadian Museum of Nature (CMN) is committed to the conservation of the monarch butterfly. The international travelling exhibition, **MONARCA . . . butterfly beyond boundaries,** was developed by the CMN in collaboration with the Canadian Nature Federation and Monarca, A.C., a Mexican group dedicated to the preservation of monarchs. A spin-off of the exhibit is the **Canada-Mexico Student Exchange Programme.** The exchange was initiated by the CMN and the *Fundación Mexicana para la Educación Ambiental A.C.* (FUNDEA). The exchange resulted from discussions during the first conference on the Conservation of Biodiversity and Biological Resources in North America (March 1994).

What is the Canadian Museum of Nature?

The Canadian Museum of Nature is much more than a natural history museum that creates and develops exhibits for public viewing. Behind our public face is a vibrant, multi-layered, multi-faceted organization composed of research scientists, collection specialists, education and multimedia specialists, and innovators.

The Museum's mission, as extracted from the mandate, is to increase, throughout Canada as well as internationally, interest in, knowledge of, and appreciation and respect for the natural world.

What is the FUNDEA?

The Foundation for Environmental Education, A.C. (FUNDEA) is a non-profit organization whose purpose is to stimulate and strengthen citizen participation in the development of their future, emphasizing the urgent need for proposals and solutions to respond to the increasing deterioration of the natural environment and quality of life.

Its main goal is to generate, disseminate and make use of scientific knowledge with the purpose of modifying behaviour that harms ecosystems. In 1988, FUNDEA received its actual site located in Tepotzotlán, State of México, as a donation. The 150-acre property has a fully equipped meeting center, and sporting facilities, as well as the Foundation's offices.

The Foundation operates three programs to achieve its objectives. Xochitla Gardens occupies most of the 150 acres. The Foundation plans plan to include a botanical garden and arboretum, a tree nursery with native species, a greenhouse, a demonstrative garden and an educational farm. It is a permanent "lung" for the metropolitan area of Mexico City. The Environmental Training Centre organizes seminars and workshops for discussion and analysis concerning topics of special relevance to the environment. It also conducts research projects and classes, and distributes information on environmental themes.

The Environmental Information Centre's objectives are to identify, capture, systematize and distribute information on water, air, soil, energy, population, environmental health, and flora and fauna management in Mexico. Under this context, the Foundation has published a series of books, which provide a diagnosis on the state of the environment in Mexico.

Travelling exhibition, MONARCA... butterfly beyond boundaries

Aimed at adults and children of all ages from a variety of cultural and educational backgrounds, the exhibit features the latest in interactive, multimedia display technologies. The goal of the international travelling exhibition is to preserve the monarch butterfly's phenomenal North American migration by conserving its northern breeding grounds and southern overwintering sites

A unique travelling exhibit, focusing on the monarch butterfly's endangered migration, began a tour of North America on June 1993 at the Canadian Museum of Nature in Ottawa. Over the past three years, the travelling exhibition has been touring the United States and Mexico where it has inspired more than a million museum visitors. Now nearing the end of the southern leg of its journey, Monarca is returning to the northern nation of its origins. The exhibition and its important conservation message will soon begin a new monumental migration as it travels across Canada and into the next millennium.

The trilingual (English, French and Spanish) exhibit presents information and distributes educational materials about the monarch's endangered migratory phenomenon, advocates actions required to preserve the butterfly's most vulnerable habitats, and helps to generate conservation funds.

The monarca exhibit has several key objectives: to emphasize the importance of a variety of vegetation, such as trees, milkweed and flowering plants, to the monarch's survival; to evoke a sense of amazement and appreciation for the monarch's life cycle and monumental migration; to increase awareness of efforts being made and those still required to protect the monarch's threatened migratory phenomenon; and to encourage museum visitors to support conservation efforts.

Canada - Mexico student exchange programme

The Canada-Mexico Student Exchange (CMSE)[1] is sponsored and organized in Canada by CMN and in Mexico by FUNDEA. The programme is now at the third edition. CMSE aims to increase understanding amongst young Canadians and Mexicans of environmental and scientific issues of importance to both countries, with particular emphasis on monarch butterfly conservation. CMSE is an excellent opportunity for students to learn about international environmental issues through direct experience.

The objective of the program is to promote scientific and cultural exchange between Canada and Mexico by means of a project carried out by students. The project is an exchange of experiences between participants from both countries. It also informs our future leaders and decision-makers about conservation issues and challenges associated with environmental protection and conservation.

This project involves hands-on science with real issues and settings, and addresses vital environmental problems such as water quality, pollution prevention and conservation of biodiversity. In Mexico, the participants experience conservation issues, reforestation of a region that was clear-cut, reproduction and propagation of fir seedlings in Angangueo, and as well as a trip to a monarch sanctuary, to the lagoon of

[1] The first exchange took place in March and June 1995 and the second in March and June 1996.

Zumpango, ecological park of Xochimilco, and to the pyramids in Teotihuacán. In Canada, the group becomes acquainted with the conservation problems associated with milkweed (the host of the monarch butterfly), breeding and raising live colonies, as well as monarch tagging. They also visit a wastewater treatment plant, meet with research scientists and visit the research collections of CMN, the National Museums, the Insectarium, the Biodome and Biosphere in Montreal.

In March, twenty Canadian students spend nine days in Mexico where they are involved in scientific and cultural activities, after which they host for nine days in June their Mexican counterparts for a similar round of activities in the Ottawa area. Students are hosted by families in both countries and/or at the FUNDEA facilities in Tepotzotlán City, to allow better interaction between the two cultures.

Cultural activities in Mexico include: a visit to the Festival of Mariposa in Angangueo; community work in Angangueo and in Tepotzotlán; a visit to the *Museo del Niño* in Mexico; a visit to Arcos del Sitio and a hacienda; a visit to the *Museo Antropología* in Chapultepec; and a visit and reception to bilingual *Scholl Rafaël Haller* in Tepotzotlán.

Cultural activities in Canada include: a visit to the parliament buildings and a special meeting with the Prime Minister of Canada; a reception at the City Hall in Hull; a visit to Heritage sites near Toronto; transplanting wild flowers in a monarch meadow near Ottawa City; and a visit to the high schools of the participants.

Selection of students

Twenty Canadian students and twenty Mexican students, between the ages of 15 and 20, are chosen for the exchange. The selection process requires that all candidates submit a 500-word essay detailing why they wish to participate and how they feel they can benefit from this opportunity. In order to recruit candidates and to provide more visibility to the programme, CMN organizes information sessions at the Museum and in different schools. Teachers, students and parents interested in taking part in a scientific and cultural exchange are invited to attend public information sessions about CMSE. Each information session includes a slide presentation about the exchange, as well as the monarch's life cycle, migration and threats it faces. The sessions also present a good opportunity to ask questions. Selected candidates are invited to prepare and present, in their respective school, an aspect of the monarch life cycle or migration, conservation issues or socio-cultural factors affecting the monarch, and to participate in all activities in both countries.

This programme is repeated every year with different groups and involves students in real scientific investigation. Ultimately, the selection of candidates is done at a national level. Two students per province and territories are chosen through a national contest to participate in the exchange, and a similar approach is taken in Mexico.

The ripple effect or the circle of influence

Although the number of participants in the exchanges was relatively small (approximately 100 in Canada) the project had the effect of stimulating their interest about the problems related to the protection and conservation of monarch butterfly and making CMN and FUNDEA known to almost all students in the schools, as well as their teachers, parents and friends. The number of people that were directly reached by the project is estimated to be 10,000 in Canada and similar or greater in Mexico. In addition, it has reached thousands of people by means of a 15-minute video, taped and produced in the monarch sanctuary and presented on a popular television show in Canada. Interviews on radio and television, as well as newspaper coverage contributed greatly to disseminate the message.

One way to measure success of the project is by observing the efforts of the participants. In Mexico as well as in Canada, all the students participated in research projects concerning the monarch life cycle and migration. The results of their work were presented at the welcoming to Canadians and Mexicans. The students spent days researching topics on their own time. Although there are no numbers available, the high level of participation demonstrated by the students shows that they have developed an interest in, knowledge of, and appreciation and respect for the natural world. Six months after the first exchange, when the Canada-Mexico Accord was signed in autumn 1995, the interest was still very high. The school bulletin boards were literally covered by clippings of articles related to conservation issues. The project created momentum.

Schools are still organizing student and teacher exchanges on different scientific and cultural aspects both in Canada and Mexico. Some students even changed their choice of career following their participation in the project.

Politicians of both countries, at all levels of government, were also involved in the project. The group of students met with the Canadian Prime Minister and federal deputies. In Ottawa, in June 1996, the Governor General of Canada, Roméo LeBlanc, the Mexican President, Ernesto Zedillo and the Ambassador of Mexico in Canada, Sandra Fuentes-Berain, took part in a special ceremony, to which the students were invited, where more than 100 monarch butterflies were released as a good-will gesture between the two countries.

Conclusion

Books, exhibits and videos are common communication and education tools by which people are sensitized to and made aware of protection and conservation of the monarch butterfly. They evoke a sense of amazement and appreciation that encourage the public to support the conservation efforts. However, there is no comparison with the in-situ experience. Participants who are able to hear the sound of millions of butterflies flying; exchange information about problems and solutions; and see the environment that the monarchs and the communities share, will always remember the unique experience they lived. Regardless of their future role in society, the students who took part in the exchange are going to be more aware of not only monarch butterfly issues but also environmental issues. They are our future environmental ambassadors.

Poster presentation

Large-scale monitoring of larval monarch populations and milkweed habitat in North America

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Abstract

A large-scale monitoring project was developed for determining the distribution and abundance of larval monarch populations during the breeding season in North America. This program has applications in the science and conservation of monarchs, as well as in fostering public participation in scientific endeavors.

A trial of the program was conducted during the 1997 breeding season. Fourteen volunteers from across the United States and Canada completed the program. Most of the participants were recruited through the Monarch Watch electronic newsgroup; others learned about the program through personal communication. Once a week, each volunteer surveyed a designated site with abundant milkweed and gathered data on milkweed quality and the abundance of monarch eggs and larvae. Milkweed quality was determined by height, age, and damage of milkweed plants, and presence or absence of flowers, seed pods, and invertebrates on the plants. Volunteers also determined the proportion of plants with different life stages of monarchs present. Sites varied from backyard gardens to nature preserves.

Contact with the volunteers was maintained through electronic mail. A distribution list was created so that participants could share their questions and ideas with each other. This program generates public interest in and awareness of monarch breeding habitat in North America, and provides useful data on monarch and milkweed populations that would be difficult to obtain without the help of volunteers. It establishes a mutually-beneficial relationship between scientists and the public and may serve as a model for future large-scale monitoring programs.

Introduction

Participants at the 1997 North American Conference on the Monarch Butterfly ranked determining patterns of monarch distribution and abundance as a major research priority that needs to be addressed in the attempt to conserve the monarch species. Here we report on the pilot year of a large-scale program to monitor larval monarch populations during the breeding season in North America. Because the project is still in its beginning stage, we refrain from reporting final results here, focusing instead on our methodology.

A primary goal of our effort is to obtain useful data to address questions about how larval monarch population densities vary in time and space. Questions that can be addressed with these data include:

1. How do monarch population densities fluctuate throughout the breeding season in different parts of North America?
2. At what immature stages does the highest mortality occur?
3. What plant qualities affect female monarch host plant choice and how does this vary between milkweed species?
4. How does monarch recruitment vary with geographical location, larval habitat size and degree of disturbance?

Some of these questions have been partially addressed by previous researchers (Borkin 1982; Malcolm et al. 1987; Swengel 1995; Zalucki et al. 1990). This research builds on their work and is part of a larger study investigating the factors that cause mortality in natural populations of monarchs, including host plant characteristics, predation, parasitoids, and pathogens, and abiotic factors.

Our second, equally important goal was to use monarch monitoring as a means to educate the public about monarchs, scientific research, and conservation. By providing non-scientist volunteers with hands-on training in field research, we hoped to improve their understanding of how science is done. Many of our volunteers were teachers, who incorporated the project into their curricula and spread the impact of this project to their students. Though most of our volunteers were already familiar with monarch life history, we also hoped to increase public interest in monarchs, especially as they exist in their breeding range. Many people are aware of the conservation issues associated with monarch overwintering sites in Mexico and California, but fewer people realize that it is also important to conserve monarch breeding habitat in the United States and Canada. As volunteers participate in this program and share their experiences with their families, friends and colleagues, more people will value that habitat as vital to monarchs and other species.

Methods

In January of 1997, we began recruiting volunteers to participate in the monitoring program. Many volunteers responded to a request posted on the Monarch Watch electronic newsgroup (Taylor, O.R. this volume). Other volunteers learned about the program by word-of-mouth. Our list of participants initially totaled 52 individuals, and we received data from individuals located in 8 states across the United States (Florida, Maine, Michigan, Minnesota, Pennsylvania, Texas, Rhode Island, and Wisconsin) and one Canadian province (Ontario). To participate, volunteers needed a monitoring site with abundant milkweed, one-to-four hours a week, and an interest in learning more about monarchs and scientific research. Some volunteers had small backyard garden sites, others monitored large fields, and still others monitored sections of nature preserves.

We designed the protocol with clarity and ease of data collection in mind, so as not to discourage participants with little background in science. We also wanted the protocol to be somewhat flexible, to allow for the needs and wants of individual participants. To achieve this goal without compromising standardization of methods among sites, we made some parts of the protocol optional. All volunteers were required to obtain certain core data, but more ambitious volunteers could choose to conduct optional activities (such as monitoring daily high and low temperatures, humidity, and rainfall). We strongly emphasized the importance of following the protocol so that we could make valid comparisons among sites.

In early spring, we mailed each participant an information packet which included directions, data sheets, and a field guide for identifying monarch larval instars. After this initial mailing, we generally communicated with the volunteers through electronic mail, since 85% of the volunteers had e-mail access. By creating a distribution list and sharing it with all participants, we were able to share individuals' questions with the whole group and solicit answers from other participants. Using the Internet greatly enhanced this project. This quick form of communication allowed us to address problems quickly and maintain a sense of camaraderie among the participants, even though most of them never met in person.

At the beginning of the monarch breeding season, volunteers recorded general information about their monitoring sites and the milkweed species present at them. Volunteers then monitored their chosen sites on a weekly basis. Monitoring was divided into two main activities: (1) recording characteristics of milkweed plants at the site, and (2) recording the number and stages of monarch larvae observed. Volunteers monitored a random sample of 30 milkweed plants at the site, recording plant height, age, damage, presence or absence of flowers and seed pods, and the number and type of invertebrates observed on the plants. Plant age was assessed on a scale of 1–3, in which: 1 = young, with new growth; 2 = mature, without new growth; and 3 = old, with signs of senescence. Plant damage was also assessed on a 1–3 scale, with: 1 = no damage, 2 = $<$25% of the leaf material damaged, and 3 = $>$25% of the leaf material damaged. Volunteers were instructed on random sampling methods, such as walking a straight-line transect through the site, stopping at a set number of paces and measuring the two nearest milkweed plants. Volunteers with small sites, such as gardens, measured all milkweed plants at the site. For the second activity, they examined as many plants as possible for the presence of monarch eggs and larvae, keeping track of the number of plants examined. When they found a monarch egg or larva, they recorded its stage (egg or number of instar), and the characteristics (e.g., height, age, etc.) of the plant on which it was found. Larval instars were identified by head capsule diameter, tentacle length, and coloration. Again, we emphasized the importance of examining a random sample of plants when looking for eggs and larvae, rather than only examining plants that appeared to be high-quality or more likely to have monarchs on them. By these methods, we were able to obtain data on the per plant density of monarchs at a site, as well as a breakdown of this density by life stage. We also obtained data on the characteristics of milkweed plants with monarchs, as compared to the average plant at the site. At the end of the season, volunteers completed a summary data sheet which included the dates and times the site was monitored, the number of plants examined for monarchs, and the number of monarchs of each stage that were found. Any disturbances at the site, such as mowing, were also recorded on the summary data sheet.

We collected the same data ourselves, at a site in west-central Wisconsin (USA). This participation allowed us to use examples from our own experience as we communicated with volunteers throughout the season.

Results

The volunteers that completed the data collection expressed enthusiasm for participating in field research and learning about monarchs and milkweed. Several volunteers felt that they had expanded their knowledge of monarch ecology. Volunteers seemed especially excited that the data they collected would actually be used by scientists, and many requested that they receive updates of the project results. Despite the initial interest in participation, and positive experience of those who collected the data, only 14 of the original 52 volunteers (27%) completed the project. Some of those volunteers who did not complete it cited the amount of time involved as a major impediment, a few lost their sites to mowing or development, and others we simply did not hear from after sending them the materials.

The data collected during the pilot year are still being analyzed and will be most useful when part of a longer-term effort. We have noted several interesting patterns in monarch abundances and are encouraged by the results to date. As an example, Figure 1 illustrates some of the data collected at a sample site in eastern Wisconsin (USA). At most sites, including this one, monarch abundance did not increase uniformly throughout the season, but showed two or more peaks in abundance (Figure 1). The timing of these peaks varied between sites. The per plant density of monarchs varied from 0 to over 1, with the highest densities at sites in Door County, Wisconsin (USA) and southern Florida (USA). Mortality appeared to be high in the egg and early instar stages at all sites, based on the densities and proportions of individuals in each stage in consecutive weeks (Figure 1). It is clear from the data illustrated in Figure 1 that eggs are much more abundant than larvae, and that early instars are more abundant than later instars.

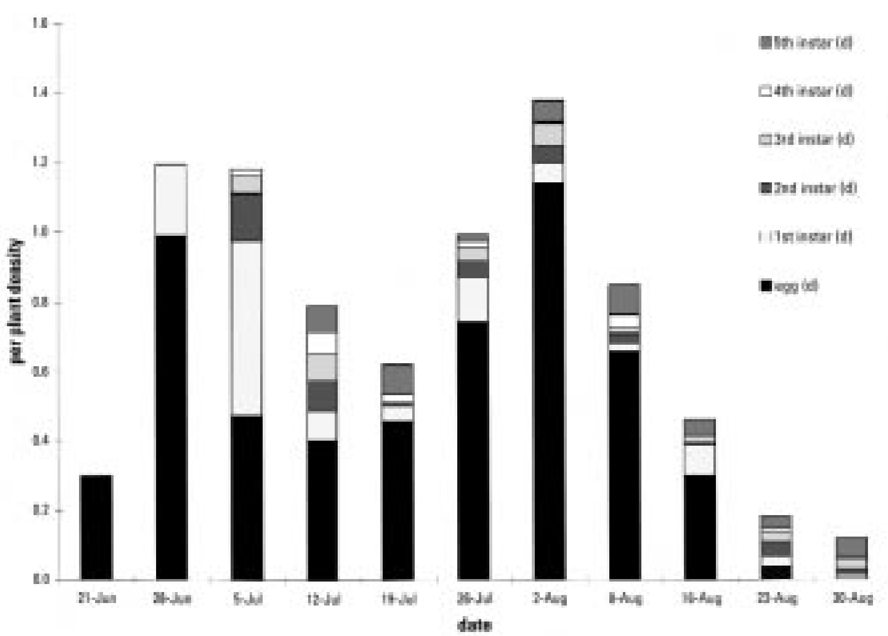

Figure 1. Per plant densities of monarch eggs and larval instars 1–5 over an 11 week period at one volunteer study site. Sample data collected by Janice Stiefel of Plymouth, Wisconsin (USA).

Discussion

With the data collected by this project, we will be able to begin answering questions about basic monarch ecology that will ultimately affect our conservation efforts. We can quantify year-to-year variation in monarch abundances across a wide geographic range, and investigate how environmental conditions such as temperature and rainfall affect these abundances. We can also compare egg and larval mortality among different geographic regions. Because of the variety of site types that are monitored, we can examine the extent to which monarchs use highly disturbed habitats, and how stage distributions vary in disturbed and undisturbed habitats.

This project also has important educational value. Participants increased their knowledge of monarch life history, and of population and community ecology in general. They learned about important scientific methods, such as observation and random sampling. This knowledge will increase their ability to make informed decisions about science and conservation issues, and certainly will increase their support of monarch conservation efforts.

Several modifications in the project will result from the pilot year. We hope to increase the percentage of volunteers who actually complete the program by offering two levels of participation. The upper level will collect data on milkweed plants and larval monarch populations, as described above. The lower level will simply collect summary data on the proportions of plants with monarch eggs and larval instars 1–5. All volunteers will collect data on the general characteristics of their sites, including data on milkweed density. We also plan to adapt the protocol in order to increase the kinds of data we can obtain through this program. Volunteers will be encouraged to collect samples of larvae to raise indoors to estimate rates of parasitism. They will also collect data on larval movement and location on plants. These data will aid our understanding of factors that influence larval foraging patterns. Finally, the method of assessing plant quality will be modified so that observers will estimate and record the percentage of leaf material eaten by herbivores and the percentage yellowed or dying, rather than use the scale of 1–3, which we found to be too subjective. We will collect all the data in electronic format, by use of an on-line database. We will also continue to collect hard copies of the data sheets to maintain quality control. We intend to continue expanding the program by soliciting more volunteers and cooperating with other organizations, such as schools and nature centers.

We did not formally assess the efficiency and accuracy of the volunteer data collection efforts during the pilot year, but much of the value of these data lies in within-site comparisons, such as changes in the relative abundances of monarchs at the same site over time. We are working personally with a subset of the current volunteers to assess their abilities and the clarity of our instructions. This assessment will allow us to continue to streamline our methodology and improve our ability to make comparisons among sites.

Acknowledgments

We thank all of the volunteers who participated in the 1997 pilot year of this monitoring program for their hard work and dedication. We especially thank Dennis Ewert, Susan Haines, C.J. Meitner, Mike Lastufka, Rod Murray, Pete and Sanny Oberhauser, Jean Orbison, Mike Quinn, Molly Schweinfurter, Gayle Steffy, Janice Stiefel, Carol Stoops, Raymond Sullivan, Lisa Tewksbury, and Sue Wait for their data.

Thank you to Kari Geurts, Liz Goehring, and Michelle Solensky for their monitoring efforts and assistance with designing the protocol for this program, and to Sonia Altizer for initiating monitoring at our site in 1995.

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Proyecto Correo Real

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Introducción

Profauna es una asociación civil preocupada desde su fundación por extender el conocimiento de los recursos naturales, por lo que se ha visto involucrada en un proceso de divulgación que dio origen a lo que ahora es su programa Educación para la Conservación. La parte más importante dentro de este programa es la capacitación para maestros en diferentes niveles y la creación de material para este fin.

A mediados de los años ochenta nos llamó la atención el hecho de que a pesar de que se conocían las áreas de invernación de la mariposa monarca y su problemática, ésta no se relacionaba con las mariposas que aparecían en cierta época del año en Coahuila y que eran perseguidas por los niños con ramas y hasta raquetas para ver quién cazaba más. Esto ponía de manifiesto el desconocimiento del fenómeno migratorio y una total falta de sensibilización para la protección de esta especie. Al mismo tiempo, nos dimos cuenta de que todos los esfuerzos estaban encaminados a proteger los lugares de invernación, pero nada se hacía por sus hábitats a través de la ruta migratoria. Además, la especie reunía las características que busca nuestra asociación para sus programas de educación, a saber: estar amenazada o en peligro de extinción, tener un valor especial y/o ser un símbolo. En el caso de la monarca se consideró también importante el hecho de que el fenómeno migratorio involucra una gran región geográfica que abarca tres países. En el territorio mexicano, este fenómeno se extiende desde la frontera norte hasta el centro del país. Estas características abren la posibilidad de una comunicación multicultural y de compartir con otras personas, por muy alejadas que estén entre sí, la inquietud por la conservación de esta gran viajera.

Con todo esto en mente, después de dos años de trabajar al respecto, en 1992 surgió formalmente el Correo Real, proyecto específicamente encaminado a la protección de la mariposa monarca durante su viaje de otoño. El proyecto está basado en los principios de educación para la conservación que rigen nuestros otros programas, esto es, en el conocimiento, la creación de conciencia y la instrumentación de acciones. Para lograr estas metas se invitó a personas de la comunidad, especialmente maestros y alumnos de escuelas de diferentes niveles, para formar una red de conservación a lo largo de la ruta migratoria de la monarca, lo cual se traduce en la participación activa en la elaboración de propuestas, la planeación y la operación de pequeñas reservas donde las mariposas descansen durante su viaje al sur. Al mismo tiempo se pretende generar actividades que permitan la protección de este y otros recursos de las regiones por las que pasan las monarca.

Metodología

La red se inició enviando cartas de invitación para participar en el proyecto a miembros de Profauna que radicaran en lugares por donde pasa la monarca. En 1993 enviamos 110 cartas utilizando el directorio de los asistentes a la reunión de la Asociación Norteamericana de Educadores Ambientales, que se llevó a cabo en San Antonio (Texas), y el Directorio Verde de Sedue. Se obtuvo un 40% de respuestas favorables. En 1994 se presentaron carteles del programa en diferentes eventos que involucraron principalmente reuniones de educadores ambientales, y se iniciaron los talleres para maestros de la localidad y ciudades cercanas. Con ello, la red aumentó a casi cien miembros más. Desde 1995, año en el que se inicia el programa de clubes ecológicos escolares de la Dirección de Ecología del Gobierno del Estado de Coahuila, se firmó un acuerdo con esta institución que nos permite presentar el Correo Real en los talleres de capacitación que al inicio del año escolar se imparten a los maestros y guías de los clubes. Los interesados se inscriben y trabajan este tema como proyecto especial. La Dirección de Ecología reúne las formas de inscripción y las entrega a Profauna, que proporciona el material didáctico. De esta manera, el Correo Real se ha extendido en los últimos tres años a casi todos los municipios de Coahuila, lo que nos ha permitido empezar a trabajar en otros lugares, como la ciudad de Monterrey y su área metropolitana. Para invitar a participar en la red a otros estados de la República, de Estados Unidos y de Canadá, se enviaron dípticos en forma de mariposa, con información del programa, a museos, centros educativos, redes de educadores ambientales, etcétera. El número de participantes de 1992 a 1997 se muestra en el cuadro 1.

Cuadro 1 **Participantes de 1992 a 1997**

Año	Núm. de participantes	Núm. de escuelas
1992	23	5
1993	80	22
1994	182	135
1995	297	227
1996	330	254
1997	812	678

El Correo Real incluye las siguientes actividades:

a. **Trabajo en el salón de clases**

Para que el maestro trabaje con la información sobre la mariposa monarca en el salón de clases, se elaboró un manual de actividades que puede utilizarse en áreas como ciencias naturales, español, geografía y ciencias sociales. Este manual incluye información sobre el ciclo de vida, la migración, los hábitats durante su viaje, las mariposas entre los antiguos mexicanos y la problemática de los sitos de invernación. Además, se presentan juegos y entretenimientos variados (sopa de letras y crucigramas, así como esquemas varios). En los talleres dirigidos a los maestros se trabaja a modo de desarrollar el proyecto en el salón de clases, y se comparten ideas y experiencias sobre cómo incluir a las mariposas en el programa escolar. La preparación del manual se inició en 1992, año en el que se contó sólo con copias fotostáticas. En 1994 se tradujo al inglés y desde 1996 se cuenta ya con versiones impresas formalmente.

b. **Monitoreo de la migración**

Se puso en marcha un intercambio de información de la migración entre los miembros del Correo Real consistente en que los participantes envían a la coordinación de Saltillo un reporte informativo sobre el arribo de las mariposas a sus comunidades. Estos reportes se dan a conocer semanalmente a todos los participantes, quienes llevan un registro de la migración colocando mariposas adhesivas en un mapa de América del Norte. El material necesario para este trabajo se entrega junto con los manuales de actividades. De esta forma, además de seguir la migración, los participantes se preparan para cuando las mariposas lleguen a su comunidad. La transmisión de información se inicia desde el momento en el que llega el primer reporte, generalmente a fines de agosto, y termina a mediados de noviembre con el arribo de las mariposas a los santuarios de los estados de México y Michoacán.

c. **Identificación de los sitios de descanso de la monarca**

Uno de los objetivos del programa es la conservación de los sitios de descanso de la mariposa monarca. Para detectarlos creamos “El árbol de las mariposas”, una actividad a través de la cual se insiste en la importancia que tienen los sitios de refugio con agua y alimento a lo largo de su ruta migratoria. Los participantes registran datos que nos permiten conocer los lugares e incluso los árboles específicos que las mariposas utilizan para descansar, las plantas de las que se alimentan, el tiempo que permanecen en cada sitio, las condiciones climáticas que en él prevalecen y el número aproximado de mariposas que llegan ahí. Al finalizar el viaje, todos los datos son enviados a la coordinación del Correo Real, donde se elabora un reporte final de actividades para ese año, que incluye todos los resultados. Cada participante recibe una copia del reporte, a fin de que cuente con la información y, en el caso de los grupos escolares, con el material necesario para discutir los resultados e iniciar nuevas actividades. Este trabajo estimula especialmente la capacidad de observación y análisis de los niños. Con los datos obtenidos a lo largo de cinco años se han planteado algunas estrategias de conservación de la monarca. El número de reportes ha crecido a lo largo del tiempo, como se muestra en el cuadro 2, de modo que la información disponible es cada vez mayor.

Cuadro 2 **Reportes recibidos por Correo Real de 1992 a 1996**

Año	Núm. de reportes recibidos
1992	82
1993	86
1994	347
1995	294
1996	1,958

d. **Salidas al campo**

Como un estímulo para los maestros que más actividades realizan dentro de este programa, cada año se organizan salidas al campo durante la época de migración. Su objetivo es observar, capturar, marcar (con etiquetas del programa Monarch Watch) y liberar a las mariposas. Los niños, felices de tener a las mariposas en sus manos aunque sea sólo por un momento, observan sus características físicas, aprenden a determinar su sexo, miden sus alas y además se familiarizan con aparatos como los termómetros, brújulas y anemómetros utilizados en la determinación de las condiciones climáticas imperantes durante el desarrollo de la actividad. A los niños se les explica que están participando en un programa científico internacional, contribuyendo al seguimiento de las mariposas a lo largo de su ruta migratoria, y que para hacerlo en México requieren de un permiso de la Dirección de Vida Silvestre. Aunque esta actividad no es la parte medular del programa, nos resulta muy importante porque tiene una gran aceptación entre los maestros y alumnos asistentes, que se convierten en fieles súbditos de la monarca. Consideramos una lástima que sólo un número muy reducido de niños pueda participar.

Resultados del programa

El principal resultado del proyecto ha sido que los maestros lo consideran una herramienta útil y novedosa en su trabajo, ya que les permite, sobre todo en los ámbitos urbanos, trabajar con un recurso natural, fomentar el intercambio de experiencias y sembrar en sus alumnos la semilla de la conservación de la naturaleza.

De las aulas han surgido programas de radio y de televisión, artículos en los periódicos locales, dos foros infantiles, campañas para que los automovilistas disminuyan la velocidad cuando las mariposas vuelan bajo, periódicos murales, boletines, festivales de bienvenida, campañas de reforestación y limpieza de los lugares donde descansan las mariposas y exposiciones de los trabajos elaborados por los niños (poesías, dibujos, canciones, maquetas, etcétera). Uno de los resultados de todos estos esfuerzos es que han desaparecido de las calles los cazadores de mariposas.

Un logro de particular importancia fue que en la ciudad de Saltillo (Coahuila) se hayan decretado como áreas protegidas municipales tres sitios donde anualmente descansan las mariposas. Además, en Ciudad Acuña (Coahuila), los maestros de la Escuela Secundaria Hermanos Flores Magón, el Club Ecológico “Lobos” y las autoridades educativas han designado el jardín de su escuela como “área protegida”. En esta misma ciudad, los maestros del Correo Real han logrado evitar la urbanización de un área verde en donde las monarcas reposan.

Es importante mencionar la colaboración de instituciones como la Dirección de Ecología del Gobierno del estado de Coahuila, que incluyó al Correo Real dentro de su programa, las direcciones de Ecología de los municipios de Saltillo y Acuña (estado de Coahuila) y de San Pedro Garza García (Nuevo León), que han apoyado la organización de los talleres; la Secretaría de Educación Pública de Coahuila, que incluyó dentro del programa escolar a las monarcas durante el mes de octubre; el Parque Ecológico Chipinque, de cuyo programa Correo Real ya es parte; la Universidad Agraria Antonio Narro, que nos permite utilizar sus viveros para las visitas de las escuelas; el Museo de las Aves, que fue sede de las exposiciones “Los niños y la monarca” y “El árbol de las mariposas” y cuyos instructores realizan actividades relacionadas con la migración durante el mes de octubre.

Un proyecto de grupo orientado hacia la conservación, como Correo Real, nos da la oportunidad de participar en un programa que tendrá repercusiones dentro y fuera de nuestras propias comunidades. Ver la reproducción de este esfuerzo nos brinda la esperanza de que nuestro futuro, común al de otras especies, puede ser mejor.

Monarch butterfly awareness through small-scale residential and community habitat enhancement efforts

by ***Craig Tufts***
National Wildlife Federation
Vienna, Virginia, United States

For almost twenty five years, through its Backyard Wildlife Habitat™ program, the National Wildlife Federation (NWF) has offered guidance and acknowledgment to those people who enhance small landscapes as habitat for a great variety of wildlife and plants. With over 20,000 properties certified in the program and a goal of doubling that number in just three years, NWF will aggressively promote the concept that everyone can take positive personal actions for wildlife and become more knowledgeable about the ecology of their communities by planting and caring for native plants that support birds, insects, reptiles, amphibians, mammals and other wildlife species.

The Backyard Wildlife Habitat™ program now actively supports schools, businesses, and a variety of communities in their efforts to conserve, create and enhance biodiverse habitat areas. There are currently over 500 schools in the United States certified in NWF's programs. NWF is also working with a number of major corporations, such as McDonald's and Bank of America to add plantings of wildife-supporting native species to a number of landscapes owned by these companies. On the community level, NWF is working with a number of churches, with Habitat For Humanity International, and is talking with the National Association of Home Builders to develop habitat enhancement guidelines for a variety of projects.

Perhaps the most significant aspect of growth for NWF's Backyard Wildlife Habitat™ programs involves the establishment of contact with many of its 20,000 participants in the United States and Canada and some 80,000 others who have requested program materials in an effort to involve them in Citizen Naturalist activities. NWF broadly defines a Citizen Naturalist as an individual who becomes involved in an organized effort to conserve, monitor, catalog, or restore species or habitats either within the property designated as their Backyard Wildlife Habitat™ or in their community. Backyard Wildlife Habitat™ participants are actively working with Save Our Streams (SOS), Monarch Watch, Project FeederWatch, Audubon Christmas Bird Counts, North American Butterfly Association's (NABA) Butterfly Counts and other citizen-driven data collecting programs.

To make participants aware of what other Citizen Naturalists are doing, Backyard Wildlife Habitat™ staff now produces a quarterly newsletter, distributed free of charge to program participant. Our Web site, www.nwf.org/habitats, regularly features news from all areas of the program and links to a number of like-minded Web sites.

In the future, NWF will support a Backyard Wildlife Habitat™ listserv permitting program participants to learn from others about their experiences in assisting wildlife, growing plants and solving community conservation problems.

NWF would like to further involve its Citizen Naturalist network in conservation of the monarch butterfly, other milkweed-linked species, and the native plants on which the monarch depends. We will reach out to a number of organizations with a strong interest in native plant conservation such as the National Wildflower Research Center, garden clubs, the Native Plant Conservation Initiative, The Nature Conservancy, state and regional native plants societies and the many groups involved in direct conservation of the monarch.

The pilot program will educate and assist our program participants who will collect and plant locally-adapted milkweed species and other wildflower seeds, and will follow through by growing them in support of monarch conservation during both the breeding season, as well as the southward fall migration. These Citizen Naturalists would not only learn much about the ecology and biology of the monarchs and other milkweed pollinators and leafy material consumers, but could serve to increase the numbers of locally adapted milkweeds, and would be a significant additional force in tagging monarchs and charting their migration and breeding success.

Please contact Craig Tufts, Chief Naturalist, National Wildlife Federation, 8925 Leesburg Pike, Vienna, VA 22184 if you would like to comment on this project proposal. You may also contact the NWF by phone at 703-790-4438; or by email at tufts@nwf.org. We look forward to working with you for monarch conservation.

Participantes
List of Participants

Homero Gómez
"El decreto debe ser revisado basándose en un estudio completo que considere al ser humano."

John Lane
"I've been so impressed at this meeting at how vital communication is—both listening and hearing, as well as mutual respect."

Steve Wendt
"In the province where I live, the province developed a policy that said all the important wetlands will be conserved. I live right across from what was designated an important wetland. I used to go there in the morning and see my favorite kinds of birds. When people heard this policy was coming in the province, landowners became frightened. So the person who owned the land across from me said "I must immediately drain that wetland before the policy takes effect." So he drained the wetland and built a house. So the effect of that policy worked backwards. Now there's a house and no birds in that area. Again, it underlines the idea that without local participation, and local acceptance of policies and laws, we won't get where we're trying to go."

Participantes/List of participants		
Name	**Organization**	**Country**
Zalucki, Myron Phillip	University of Queensland	Australia
Aiken, Robert	Concordia University	Canada
Dansou, Kafui	International Model Forest Network Secretariat	Canada
Davis, Donald A.	The Friends of Presqu'île Park	Canada
Dickson, Kathy	Canadian Wildlife Service	Canada
Emery, Rosie	Rainbow Road Tour	Canada
Gauthier, David	Canadian Plains Research Center, University of Regina	Canada
Hobson, Keith	Environment Canada	Canada
Johnson, Fred	International Model Forest Network Secretariat, International Development Research Centre	Canada
Lauriault, Jean	Canadian Museum of Nature	Canada
Maxwell, Colin	Canadian Wildlife Federation	Canada
Patry, Marc	Eastern Ontario Model Forest Network	Canada
Price, Steven	World Wildlife Fund	Canada
Wassenaar, Leonard	Environment Canada	Canada
Wendt, Stephen	Canadian Wildlife Service	Canada
Adame Cisneros, Jorge	Facultad de Ciencias, UAEM	México
Aguilar Delgado, Ruth	Confederación Nacional Campesina	México
Alcántara, Francisco	Comisario Ejidal de El Encino	México
Alfaro Mercado, Deyanira	Particular	México
Alfredo, José	Representante del ejido S. J. Ixtapa	México
Alonso Olvera, Lucía Yolanda	INE	México
Alva de la Colina, Eduardo	UAEM	México
Álvarez Nava, Pedro	Comisario ejidal de R. P. Amarillo	México
Álvarez-Alcalá, José Luis	The La Cruz Habitat Protection Program and Reforestation Project	México
Ángeles, Santos	Comisario ejidal de Ocampo	México
Angulo Carrera, Alejandro	Profepa, México	México
Apolinar de Jesús, Bernardo	Profepa, México	México

Arévalo Navarro, Patricia	Particular	México
Arévalo Navarro, Raquel	UMSNH	México
Argueta Contreras, Damar	Ejido El Rosario	México
Argueta, Federico	Ejido Ocampo	México
Ayala Luna, Jose Efraín	Secretaría de Desarrollo Urbano y Ecología	México
Baca Díaz, Antonio	Copromo	México
Baeza, Roberto	Representante del ejido C. Cárdenas	México
Barkin, David	Universidad Autónoma Metropolitana	México
Barrios, Hiram	Profepa, México	México
Bello Guevara, Jorge Fernando		México
Benavides Z., Beatriz	INE	México
Bernal Gallegos, Maricela	Presidente municipal de Ocampo	México
Bernal, Marco	INE, México	México
Betancourt, José Luis	INE, México	México
Bocco, Gerardo	Instituto de Ecología, UNAM	México
Bolaños, Guido	WWF	México
Calvo Estrada, Ireri	Profepa	México
Caro, Rosendo A.	Semarnap, Michoacán	México
Castañeda P., Javier	WWF	México
Castillo, Alicia		México
Castrejón, Marco Brito	Semarnap	México
Cendejas Guízar, Josefina	UMSNH	México
Chaparro, Cristino	Representante P.P. S. J. Ixtapa	México
Chávez, Yolanda	INIFAP	México
Contreras, Ceferino	Comisario ejidal de S. J. Zitácuaro	México
Correa Pérez, Jorge	Conacyt	México
Correa Quintana, Teodulfo	Representante del Comité Ejido Zaragoza	México
Correa, Guadalupe	Comisario ejidal de Zaragoza	México
Covarrubias D., Alfonso	Semarnap	México
Crespo, Luis Felipe	Reserva de la Biosfera Mariposa Monarca	México

Cruz Merlos, Alfredo	Triple SSS - Reserva de la Biosfera Mariposa Monarca	México
Cruz, Raúl	Comisario ejidal de San Juan Xoconusco	México
De la O, Jaime	C. I. S. Ma. y sus Barrios	México
Del Río, Guadalupe	Alternare, AC	México
Delgadillo Ramírez, Joel	Secretaría de Ecología, estado de México	México
Díaz Vázquez, Jaime	Red Mocaf	México
Díaz, Jerónimo	Comisario ejidal de S. J. Ixtapa	México
Díaz, Joaquín	Comisario ejidal de La Rosa	México
Díaz, José	Representante del ejido S. J. Ixtapa	México
Díaz, Martín	Representante del Comité Ejido S. J. Ixtapa	México
Díaz, Rafael	Representante del Comité Ejido S. J. Ixtapa	México
Domínguez Cárdenas, Raúl	Comisión Forestal, estado de Michoacán	México
Durán Gálvez, Blanca	Profepa	México
E. Saldaña, Lizzett Araceli	CBTIS 149	México
Echaniz, Paula	GIRA, A.C.	México
Escalante Linares, Omar	UMSNH	México
Espino García, Ángel		México
Espinoza Núñez, Beatriz Abigaíl	Sedesol	México
Esquivel, Ana Elena	Centro Educativo Morelia	México
Estrada Rodríguez, María Cruz		México
Estrada, Faustino	Comisario ejidal de El Capulín	México
Flores, Avelino	Ejido Santa Ana	México
Flores, Francisco	Representante del ejido Pueblo Nuevo Solís	México
Gabriel, Antonio	Comisario ejidal de S. J. Totoltepec	México
Galas Salazar, J. Fernando	Servicios Técnicos Forestales	México
García González, Raúl	Comisario ejidal de El Rosario	Mexico
García de la Paz, Daría	Ejido de San Juan Xoconusco	México
García García, Francisco	Comisario ejidal de San Francisco de Los Reyes de Michoacán	México
García Garrido, Víctor Hugo	Semarnap	México

García S., Guadalupe	Comunidad Indígena de San Cristóbal	México
García Vázquez, Mariano	Guardianes de la Monarca, AC	México
García, Antonio	Alianza de Ejidos y Comunidades de la Reserva de la Mariposa Monarca	México
García, J. Socorro	Comunidad Indígena de Cresencio Morales	México
García, Jaime	Comunidad Indígena de San Cristóbal	México
García, Juan	Comisario ejidal de Pueblo Nuevo Solís	México
García, Marcelino	Comunidad Indígena de Ojeda	México
García, Miguel	Representante del Comité Ejido P. Nuevo Solís	México
Garduño, Raúl	Comisario ejidal de San Felipe de Jesús	México
Garza, Máximo	Senarnap estado de México	México
Gausin, Baltazar	Comisario ejidal de Contepec	México
Gómez Flores, Alberto	UNORCA	México
Gómez González, Homero	Ejido El Rosario	México
Gómez Gutiérrez, Germán	Semarnap	México
Gómez Tagle, Agustín	INE	México
Gómez-Tagle, Alberto	Instituto Nacional de Investigaciones Forestales y Agropecuarias	México
González Jácome, María Ofelia		México
González, Francisco	Comunidad Indígena de Francisco Serratos	México
Granados Delgado, Karen	UMSNH	México
Grenon Cascales, Graciela Noemí	UAEM	México
Grobet Vallarta, Luciano	Semarnap	México
Guridi Gómez, Lydia Isabel	UMSNH	México
Gutiérrez H., Héctor		México
Guzmán, Federico	Ejido Asoleadero	México
Guzmán, Lorenzo	Ejido Asoleadero	México
Hernández D., Salvador	Semarnap	México
Hernández López, Velia	UMSNH	México
Hernández Mondragón, María	UMSNH	México
Hernández, Helia		México

Hernández, Juan	Ejido El Encino	México
Hernández, Teresa	Ejido Arroyo Seco	México
Hinojosa, Alfredo	Ejido R. Ahorcados	México
Hoth Von Der Meden, Jurgen	Embajada de México en Canadá	México
Iñigo, Eduardo	Fondo Mundial para la Naturaleza	México
Jerónimo, Juan	Ejido Contepec	México
Jiménez C., María de Lourdes	Secretaría de Turismo Delegación Zitácuaro	México
Jiménez, Alfredo	Ejido A. de Juárez	México
Juárez Ochoa, Ivonne		México
Leocadio, David	Comunidad Indígena de Malacatepec	México
León, Cuauhtémoc	El Colegio de México, Programa "Lead"	México
Leticia Navarios, Alejandra	UMSNH	México
Leyva López, Juan Antonio	Profepa	México
López, Esteban	Ejido Sn. J. Xoconusco	México
López G., Erna Martha	UMSNH	México
López Hernández, Rigoberto	Parque Nacional "Barranca del Cupat."	México
López Miranda, Rosalía	ISSSTE	México
López Mora, Juan Daniel	UMSNH	México
López Sánchez, Edilberto	Semarnap	México
López, Antonio	Ejido San Xoconusco	México
López, Frine	Espacio Autónomo	México
López, Jesús	Comunidad Indígena de San Xoconusco	México
Macaria Mejía, María	Ponente	Mexico
Madrigal Uribe, Delfino	Facultad de Geografía, UAEM	México
Madrigal, Teresa C.	Comisión Forestal, gobierno de Michoacán	México
Madrigal, Xavier	UMSNH	México
Magaña Mendoza, José Luis	UMSNH	México
Maldonado Hernández, Carlos	Desarrollo Urbano	México
Manuel de Jesús, Jesús	Comunidad Indígena de San Felipe los Alzati	México
Martínez Ramírez, Nereida		México

Martínez Rangel, Serafin		México
Martínez Tapia, Miguel	Profepa	México
Martínez, Alejandro	Ejido Angangueo	México
Martínez, Carmen	Ejido Cerro Prieto	México
Martínez, Odilón	Ejido El Paso	México
Mas Porras, Javier	Copromo	México
Masera, Diego	GIRA, AC	México
Mata García, Elizabeth	Secretaría de Fomento Económico	México
Maya, Alfredo	Comunidad Indígena de Carpinteros	México
Medina, Gervasio	Ejido Chincua E. Z.	México
Mejía Medina, Abel	Ejido Senguio	México
Mejía Ramírez, Saúl	UMSNH	México
Mejía Torres, Alfonso	UMSNH	México
Meltis, Fabio		México
Mendera Cantú, Manuel	Instituto de Ecología, UNAM	México
Mendieta Vargas, Víctor Manuel	Ejido San Juan Xoconusco	México
Mendoza Hernández, Pilar	Instituto de Ecología, UNAM	México
Merino Pérez, Leticia	Centro Regional de Investigaciones Multidisciplinarias, UNAM	México
Miranda, Roberto	Ejido de Jesús Nazareno	México
Missrie, Mónica	Traductora	México
Mondragón, María	Ejido Los Remedios	México
Montecinos, Eneida	Ponente	México
Mora Álvarez, Blanca	Dirección de Reserva de la Biosfera de la Mariposa Monarca	México
Mora García, Miguel Ángel	Semarnap	México
Morales, Berenice	Ejido Rincón de Soto	México
Moreno Cuiniche, Salvador	Secretaría de Educación Pública	México
Moreno Flores, Shayuri		México
Moreno Ramos, Cuauhtémoc	Semarnap	México
Moreno, Julio	Ejido Cerro Prieto	México

Muñiz, Ana María	Alternare, AC	México
Muñoz, Peña	Vive México, AC	México
Navia Antezan, Jaime F.	GIRA, AC	México
Ochoa Blackaller, Cecilia	Secretaría de Desarrollo Social de Coahuila	México
Olivares Gonzales, Ana María		México
Olivares González, Isabel	Particulares	México
Ordóñez, Antonio Benjamín	Instituto de Ecología, UNAM	México
Orduña Trejo, Constantino	INIFAP	México
Orizaba Sandoval, Ranulfo	Semarnap	México
Ortega, Moisés	Ejido El Encino	México
Ortiz, Eliseo	Comunidad Indígena de San Juan Zitácuaro	México
Pallares, Eugenia	Sierra Madrigal, El Aire	México
Parra, Carmen	El Aire, Centro de Arte	México
Pavón Romero, Sergio Humberto	UAEM	México
Peláez, Alejandro	Semarnap	México
Peña Aguilar, Estela		México
Peralta, Martín	Ejido Sta. María Ahogada	México
Pérez O., Antonio	Banco de México	México
Priego, Karla	Semarnap	México
Quintero, Rubén		México
Ramos Solorio, Guillermo	Instituto Nacional Indigenista	México
Rendón, Eduardo	UNAM, Instituto de Biología	México
Revuelta, Milagros	Orquidario de Morelia	México
Reyes Domínguez, Jesús	Alianza de Ejidos y Comunidades	México
Reyes, Jesús	Ejido 2ª. F. Calabozo	México
Rivera Moctezuma, Honorio		México
Rodríguez, José Luis	Ejido San Francisco Reyes	México
Rojas C., Héctor Andrés	UMSNH	México
Rosete Verges, Fernando Antonio	Semarnap	México
Ruiz García, Pedro	Ejido Varechiquichuca	México

Ruiz Vásquez	Semarnap	México
Saavedra Peláez, Fernando	Conapo	México
Sada Zambrano, Andrés M.		México
Sáenz Reyes, Trinidad	INIFAP	México
Salazar, Benigno	INE	México
Salazar, Fernando	Comisario Ejidal Cto. Cárdenas G.V.	México
Saldívar, Neri	Pequeño propietario S. J. Ixtapa	México
Saldívar, Salomé	Pequeño propietario S. J. Ixtapa	México
Sanabria, Bernabé		México
Sánchez Brito, Carlos	INIFAP	México
Sánchez García, Manuel	Ejido La Mesa, Municipio de San Felipe	México
Sánchez P., Ramiro	UMSNH	México
Sánchez, Florentino	Ejido Nicolás Romero	México
Sánchez, Gabriel	Alternare, AC	México
Santacruz R., Armando	Parque Nacional "Barranca del Cupat."	México
Santiesteban, Nena Cortés	Ecomorelia	México
Santos, Esteban	Ejido Nicolás Romero	México
Saucedo, Noé	Ejido Contepec	México
Smialkoski, Lelia		México
Solís Hernández, Miriam Andreli	Centro Educativo de Morelia	México
Solís, Guadalupe	Ciidir Instituto Política Nacional, Mich.	México
Suárez Medina, José	UMSNH	México
Suárez, Lupita		México
Tapia, Silverio	Ejido Jesús Nazareno	México
Téllez, Abel	Ejido Santa Ana	México
Téllez, Ángel	Ejido Emiliano Zitácuaro (San Juan)	México
Toledo B., Abdias	Comisión Federal de Electricidad, Geotermia	México
Toledo, Víctor Manuel	Instituto de Ecología, UNAM	México
Toribio, Martín	Ejido Buenavista C.	México
Torres García, Alejandro	Instituto de Ecología, UNAM	México

Torres Gonzales, Serafín	Presidente municipal de Angangueo	México
Torres Morales, Víctor Manuel	Alianza de Ejidos	México
Torres, Faustino	Ejido Senguio	México
Treviño, Rocío	Semarnap, Michoacán	México
Urbina, Tomás	Ejido La Mesa	México
Valdez, César	Pequeño propietario San Jesús Ixtapa	México
Vanegas, Bonifacio	Comunidad Indígena de San Cristóbal	México
Vargas García, Carlos Ricardo	SDAF, gobierno de Michoacán	México
Vavarrete, Juan Castillo	UNAM	México
Vega Ruiz, Primitivo	Ejido San Felipe Los Alzati	México
Vega, Arévalo	Central Nacional Campesina	México
Velázquez, Alejandro	UNAM	México
Velázquez, Fidencio	Ejido Varechiquichuca	México
Venegas, Álvaro	Ejido 1ª. F. Calabozo	México
Venegas, Ángel		México
Vergara, Guillermo	Ejido Corrales	México
Vieyra, Samuel	Ejido Hervidero y Plancha	México
Villa Castillo, Benjamín		México
Villanueva Villanueva, Lorena	UMSNH	México
Villaseñor R., Francisco Javier	INIFAP	México
Vinicio Meza, Jesús	Semarnap	México
Wing Martínez, Marco Antonio		México
Yáñez C., L.	Ejido Rondanilla	México
Yáñez, Cecilia	Ejido Rincón de Soto	México
Zepeda Castro, Hugo	UMSNH	México
Aguilar, Mary Alice	Redding Intermediate School	United States
Alonso, Leeanne	Xerces Society	United States
Alonso Mejía, Alfonso	Smithsonian Institution/Measuring, Monitoring and Assessment of Biodiversity Program	United States
Altizer, Sonia	University of Minnesota	United States
Angelo, Christine	Medio Ambiente	United States

Arnott, Christine	Monarch Program	United States
Bray, David	Florida International University	United States
Brower, Lincoln P.	University of Florida and Sweet Briar College	United States
Calvert, William H.	University of Florida and Texas Parks and Wildlife Department	United States
Castillo De Ramos, Isabel	WRI	United States
Chavarria, Gabriela	National Fish and Wildlife Federation	United States
Cherubini, Paul		United States
Dockx, Christina	University of Florida	United States
Donnelly, Elizabeth	Journey North	United States
Frey, Dennis	California Polytechnic State University	United States
Gendron, Bobby		United States
Gibbs, Shannon	University of Florida	United States
Goehring, Liz	University of Minnesota	United States
Halpern, Sue	Audubon Magazine	United States
Hamlin, Sandra	Audubon Society/Monarch Watch	United States
Hundley, Christopher		United States
Lane, John		United States
Leong, Kingston	California Polytechnic State University	United States
Malcolm, Steven B.	Western Michigan University	United States
Manion, Christian	Monarch Program	United States
Marks, Jane	USAID	United States
Marriott, David	Monarch Program	United States
Meitner, C.J.	Hiawatha National Forest	United States
Meitner, Gary H.		United States
Monroe, Mia	The Monarch Program and National Park Service, USDI	United States
Oberhauser, Karen	University of Minnesota	United States
Oberhauser, Peter		United States
Oberhauser, Suzanne		United States
Perez, Sandra M.	University of Arizona	United States

Prysby, Michelle	University of Minnesota	United States
Raffaele, Herbert A.	US Fish and Wildlife Service	United States
Rashin, Ed	The La Cruz Habitat Protection Program and Reforestation Project	United States
Rice, John	Associated Press	United States
Schappert, Phil	York University	United States
Small, Robert L.	The La Cruz Habitat Protection Program and Reforestation Project	United States
Solensky, Michelle J.	University of Minnesota	United States
Stell, Gary	Monarch Garden	United States
Stifel, Doris	Nature Conservancy	United States
Tajkbakhsh, Melida	US Fish and Wildlife Service	United States
Talesfore, Michael	Magical Beginnings Butterfly Farms	United States
Taylor, Orley R.	University of Kansas	United States
Tufts, Craig	National Wildlife Federation	United States
Van Hook, Tonya	University of Florida and Tall Timbers Research Station	United States
Vasconsellos, Jeff	Naturalist	United States
Wagner, Matt W.	Texas Parks and Wildlife Department	United States
Weiss, Stuart B.	Stanford University	United States
Wijesuriya, Kumari	California Polytechnic State University	United States
Yeager, Brooks	US Department of the Interior	United States
Pisanty, Irene	Commission for Environmental Cooperation	Can/Mx/USA
Stoub, Jeffrey	Commission for Environmental Cooperation	Can/Mx/USA
Villeneuve, Leticia	Commission for Environmental Cooperation	Can/Mx/USA
Vincent, Rachel	Commission for Environmental Cooperation	Can/Mx/USA
Wilkinson, Tara	Commission for Environmental Cooperation and Mcgill University	Can/Mx/USA

Agenda

Reunión de América del Norte sobre la Mariposa Monarca
North American conference on the monarch butterfly
Centro de Convenciones
Morelia, Michocán
Noviembre / November 1997

Lunes 10/Monday 10

Sesión matutina/Morning session

Salón Michoacán I

Reunión de América del Norte sobre la Mariposa Monarca— Ceremonia de Inauguración
North American conference on the monarch butterfly—Opening Ceremony

Presentación de los miembros del Presídium/Presentation of the members of the Presidium

Bienvenida/Welcome

Víctor Manuel Tinoco Rubí, Gobernador, Michoacán

César Camacho Quiroz, Gobernador, Estado de Mexico

Presentación de la reunión/Presentation of the Conference

Javier de la Maza Elvira, Coordinador nacional del Sistema de Áreas Naturales Protegidas

The importance of cooperation among the countries of North America for the protection and conservation of the monarch butterfly

Víctor Lichtinger, Executive Director, Commission for Environmental Cooperation

Steven Wendt, Chief, Migratory Birds Conservation, Canadian Wildlife Service, Environment Canada

Bruce Babbit, Secretary, United States Department of the Interior

Julia Carabias Lillo, Secretaria, Secretaría de Medio Ambiente, Recursos Naturales y Pesca de México

Bienvenida oficial/Formal opening

Presentaciones/Presentations

Sesión matutina/Morning session

Salón Michoacán I

Biología de la Mariposa Monarca/Biology of the Monarch Butterfly
Presidente de la sesión/President of the Session: Phil Schappert

Karen Oberhauser[1] **and Dennis Frey**[2] (USA)
[1] Department of Ecology, Evolution and Behavior, University of Minnesota
[2] Biological Sciences Department, California Polytechnic State University
-*Coercive mating by overwintering male monarch butterflies*

Dennis Frey (USA)
Biological Sciences Department, California Polytechnic State University
-*Resistance to mating by female monarch butterflies*

Liz Goehring (USA)
Department of Ecology, Evolution and Behavior, University of Minnesota
-*Environmental induction of reproductive diapause in* Danaus plexippus

Tonya Vanhook (USA)
Department of Entomology, University of Florida, Tall Timbers Research Station
-*The use of bursa copulatrix dissection and abdominal palpitation to assess female monarch butterfly mating status*

Salón Michoacán II

Desarrollo y sustentabilidad—Conservación I
Development and Sustainability—Conservation I
Presidente de la sesión/President of the Session: Jürgen Hoth

Leticia Merino (México)
Consejo Civil Mexicano para la Silvicultura Sostenible, AC, y Centro Regional de Investigaciones Multidisciplinarias
La región de la Reserva de la Biosfera Mariposa Monarca: problemática general

Cuauhtémoc León (México)
El Colegio de México Programa Lead
Dinámica socioambiental y ordenamiento ecológico: retos para un diagnóstico operativo

Alberto Gómez Tagle, **Yolanda Chávez** (México)
Instituto Nacional de Investigaciones Forestales, Campus Morelia
El sistema agrológico forestal como base para el diagnóstico-manejo forestal integrado en la reserva Chivatí-Huacal, porción El Paso, Ocampo, Michoacán, México

Carmen Parra, **Ofelia Pallares** (México)
El Aire, Centro de Arte
Un fideicomiso para la protección de Sierra Chincua, Michoacán

Sesión vespertina/Afternoon session

Salón Michoacán I

Biología de la mariposa monarca/Biology of the Monarch Butterfly
Presidente de la sesión/President of the Session: Karen Oberhauser

William Calvert and Matt Wagner (USA)
University of Florida and Texas Parks and Wildlife Department
Patterns in the monarch butterfly migration through Texas, 1993–1995

Christina Dockx (USA)
Department of Biology, University of Florida
-Migración de la mariposa monarca a Cuba

David Marriot (USA)
Monarch Program
-Overwintering population dynamics of monarch butterflies, Danaus plexippus, *in Northern Baja California, Mexico*

Lincoln Brower (USA)
Department of Biology, University of Florida and Sweet Briar College
-Sugar content of flowers and in the crops of the monarch butterfly overwintering in Sierra Chincua: suffering flowers and starving butterflies

Sandra Pérez (USA)
Department of Ecology, Univerrsity of Arizona
-Testing monarch butterfly orientation in the field during the autumn migration

Orley Taylor (USA)
Department of Entomology, University of Kansas
-Mark and recapture during the monarch migration: a preliminary analysis

Eligio García y Xiomara Mora (México)
Reserva Especial de la Biosfera Mariposa Monarca, INE

-Monitoreo de las colonias de mariposa monarca en los sitios de invernación en México

Keith Hobson and Leonard Wassenaar (Canada)
Environment Canada
-Linking natal origins and wintering roost sites of monarch butterflies, using stable isotope signatures

Hiram Barrios Rivera (México)
Procuraduría Federal de Protección al Ambiente
Monitoreo de la mariposa monarca en la Reserva de la Biosfera Mariposa Monarca - Temporada 1996-97

Eduardo Rendón, **Alfonso y Miguel Franco** (México)
Instituto de Biología, Smithsonian Institute e Instituto de Ecología, UNAM
-Regeneración de los bosques de oyamel en las áreas protegidas de la mariposa monarca en México

Alfonso Alonso (USA)
Smithsonian Institute, Measuring, Monitoring, and Assessment of Biodiversity Program
Scientific research and social investigation priorities for the Monarch Butterfly Special Biosphere Reserve: recommendations

Eneida Montecinos, **Eduardo Rendo**, **Alfonso Alonso y Ken Oyama** (México)
Instituto de Ecología, UNAM
-Predation of the monarch butterfly in their overwintering sites: Implications for conservation

Biología de la mariposa monarca: Conclusiones/Biology of the Monarch Butterfly I: Conclusions

Salón Michoacán II

Desarrollo y sustentabilidad—Conservación I
Development and Sustainability—Conservation I
Presidente de la sesión/President of the Session: Leticia Merino

Silverio Tapia (México)
Ejido Jesús de Nazareno, municipio de Angangueo, Michoacán
-Retos para la conservación de los bosques de la región de la mariposa monarca

Luis Meneses (México)
Union Nacional de Organizaciones Regionales Campesinas Autónomas
-Tenencia de la tierra y mariposa monarca

Silvano Aureoles (México)
Red Mexicana de Organizaciones Campesinas Forestales, AC
El desarrollo regional sustentable y la mariposa monarca

Rosendo Caro (México)
Subdelegación de Recursos Naturales, Delegación Semarnap en Michoacán
-El desarrollo regional en la Reserva Especial de la Biosfera Mariposa Monarca

Gonzalo Chapela (México)
Director General de Restauración y Conservación de Suelos
-Algunas líneas para el desarrollo sustentable en la región de la mariposa monarca

Guadalupe Treviño y Agustín Tagle (México)
Reserva de la Biosfera de la Mariposa Monarca, INE
Sujetos sociales, participación y gestión comunitaria: una propuesta metodológica de participación social para la Reserva Especial de la Biosfera Mariposa Monarca

Pascual Sigala (México)
Alianza de Ejidos y Comunidades de la Reserva Mariposa Monarca, AC
-La conservación de la mariposa monarca, reto para la organización campesina

José Luis Betancourt (México)
Reserva Especial de la Biosfera Mariposa Monarca (REBMM), INE
-Toma de decisiones en ejidos y comunidades indígenas de la REBMM

David Barkin (México)
Universidad Autónoma Metropolitana
Dos milagros: monarcas y campesinos

Benigno Salazar (México)
Reserva Especial de la Biosfera Mariposa Monarca, INE
-Determinación de la capacidad de carga turística del centro ecoturístico de la mariposa monarca "El Rosario"

Alejandro Angulo (México)
Procuraduría Federal de Protección al Ambiente
La mariposa monarca y el cumplimiento de la ley

Jacinto Jiménez, Cristóbal Urbina Pastenes, Guillermo Moreno Cárdenas e Ismael Venegas (México)
Procuraduría Federal de Protección al Ambiente
El áera de protección social: ilícitos en la protección de la Reserva Especial de la Biosfera Mariposa Monarca

Bernardo de Jesús Apolinar (México)
Procuraduría Federal de Protección al Ambiente
-Reporte preliminar de la evaluación económica de la pérdida del valor de la tierra en la Reserva Especial de la Biosfera Mariposa Monarca

Marco Bernal y Alejandro Camacho (México)
Reserva Especial de la Biosfera Mariposa Monarca, INE
-Análisis crítico del manejo de la REBMM: perspectivas y alternativas

Jürgen Hoth (México)
Agregado para Asuntos Científicos y Ambientales, Embajada de México en Canadá
-Mariposas monarca: Retos compartidos en el Norte de América

Desarrollo y sustentabilidad—Conservación I: Conclusiones
Development and Sustainability—Conservation I: Conclusions

Martes /Tuesday 11

Presentaciones/Presentations

Sesión matutina/Morning session

Salón Michoacán I

Biología de la mariposa monarca II/Biology of the Monarch Butterfly II
Presidente de la sesión/President of the Session: Ken Oyama

María Macaria Mejía *(México)*
Distribución y superficie de las colonias de mariposa monarca en el estado de Michoacán, México; temporada 1984–1991

Bobby Gendron (USA)
Student
-Northern California milkweeds

Steven Malcolm (USA)
Department of Biology, Western Michigan University
The lethal plant defense paradox and the influence of milkweed latex on larval feeding behavior of the monarch butterfly

Myron Zalucki (Australia)
Department of Entomology, University of Queensland
-Estimating the effect of climate on the distribution and abundance of the monarch butterfly, Danaus plexippus: *a tale of two continents*

Ken Oyama, **Eneida Montecinos** y **Eduardo Rendón** (México)
Instituto de Ecología, Campus Morelia, UNAM
-Genética de la mariposa monarca

Sonia Altizer, **Karen Oberhauser**1 **and Lincoln Brower**[2] (USA)
[1] Department of Ecology, Evolution and Behavior, University of Minnesota
[2] University of Florida and Department of Biology, Sweet Briar College
-Host migration and the prevalence of the protozoan parasite, Ophryocystis eledtroscirrha, *in natural populations of adult monarch butterflies*

Conferencia magistral/Keynote Lecture

Lincoln Brower (USA)
Department of Biology, University of Florida and Sweet Briar College
Biological necessities of the monarch butterfly overwintering in relation to the oyamel forest ecosystem in Mexico

Salón Michoacán II

Educación ambiental/Environmental Education
Presidente de la sesión/President of the Session: Orley Taylor

Elizabeth Donnelly (USA)
Journey North
Journey North: Tracking the migration ever the internet

Rocío Treviño (México)
Protección de la Fauna Mexicana, AC
Correo Real: La ruta migratoria de la mariposa monarca

Liz Goehring and Karen Oberhauser (USA)
Department of Ecology, Evolution and Behavior, University of Minnesota
Monarchs in the classroom, a K-12 ecology education program

Orley Taylor (USA)
University of Kansas
Monarch Watch: education, conservation and research

Mariano García (México)
Guardianes de la Monarca, AC
Mariposas monarca y educación ambiental

Catarina Illsley (México)
Grupo de Estudios Ambientales
Recursos naturales y su aprovechamiento en el área de la Reserva Especial de la Biosfera Mariposa Monarca

Luis Felipe Crespo y Fabio Meltis (México)
Reserva Especial de la Biosfera Mariposa Monarca y Organización Cultural Internacional, AC
Ecomuseo de la mariposa monarca: Una estrategia de educación ambiental, comunicación alternativa y manejo de una área natural protegida

Sesión vespertina/Afternoon session

Salón Michoacán I

Desarrollo y sustentabilidad—Conservación II
Development and Sustainability—Conservation II
Presidente de la sesión/President of the Session: Gerardo Bocco

John Lane (USA)
-If you open the forest, will the butterflies come? A review of 100 years of development on California's Monterey peninsula

Ed Rashin, **Robert Small and José Luis Álvarez Alcalá** (USA)
The Michoacán Reforestation Fund and The La Cruz Habitat Protection Project
-Reforestation as a strategy for restoring monarch ecosystems

Kingston Leong (USA)
Department of Entomology, California Polytechnic State University
-A restoration study of an overwintering grove in Los Osos, San Luis Obispo County, California

Phil Schappert (Canada)
Department of Biology, York University
-Distribution, Status and Conservation of the monarch butterfly, Danaus plexippus *(L.), in Canada*

Matt Wagner (USA)
Texas Parks and Wildlife Department
-Monarch conservation efforts of the Texas Parks and Wildlife Department

Xavier Madrigal (México)
Universidad Michoacana de San Nicolás de Hidalgo
-Las comunidades de vegetación primaria en el oriente del estado de Michoacán, México

Omar Masera, Diego Masera y Jamie Navia (México)
Instituto de Ecología, UNAM, Campus Morelia, y GIRA, AC
-Conservación y restauración forestales: retos y oportunidades a partir de un estudio sistémico de la demanda de productos forestales

Fred Johnson (Canada)
International Model Forest Network, International Development Research Centre
-Model Forests and the International Model Forest Network

Diana Ponce (México)
Coordinadora de Política Internacional, Subsecretaría de Recursos Naturales
-La cooperación internacional como apoyo al desarrollo social. El caso Bosque Modelo

Gerardo Bocco, **Alejandro Torres y Alejandro Valázquez** (México)
Instituto de Ecología, UNAM, campus Morelia
Recursos naturales y sistemas de información geográfica en comunidades indígenas en el centro de México

Shannon Gibbs (USA)
Department of Entomology, University of Florida
-*Satellite monitoring of the Oyamel forest monarch butterfly overwintering sanctuaries in Mexico*

Delfino Madrigal (México), UNAM
-*Bases para el diseño de un sistema de información geográfica en el ordenamiento territorial de las reservas de la mariposa monarca*

Desarrollo y sustentabilidad— Conservación II: Conclusiones
Development and Sustainability—Conservation II: Conclusions

Salón Michoacán II

Educación ambiental/Environmental Education
Presidente de la sesión/President of the session: Jean Lauriault

Donald Davis (Canada)
The Friends of Presqu'ile Park
-*Urquart Butterfly Garden*

Ana María Muñiz, **Gabriel Sánchez**, **Guadalupe del Río y Elia Hernández** (México)
Instituto Mexicano de Recursos Naturales Renovables, AC
-*Participación comunitaria: un proceso a largo plazo en el manejo y aprovechamiento de recursos naturales*

Leonardo Meza (México)
Fundación Friedrich Ebert
-*Educación ambiental: herramienta para la conservación*

Jean Lauriault (Canada)
Canadian Museum of Nature
-*Education beyond boundaries — the monarch butterfly*

Rosie Emery (Canada)
Pathways: Concepts in environmental education, Inc.
-*Rainbow Road Tour*

Gabriela Alejandra Pérez (México)
Instituto Tecnológico Autónomo de México
-*Valuación económica de los beneficios recreativos del santuario de la mariposa monarca*

María Macaria Mejía *(México)*
Educación informal para el manejo turístico del Santuario El Rosario de la mariposa monarca, municipio de Ocampo, Michoacán

Tiahoga Ruge (México)
CISEANA
-*El papel de la comunicación en la participación de la monarca*

Craig Tufts (USA)
National Wildlife Federation
-*Monarch butterfly awareness through small scale residential and community habitat enhancement efforts*

Educación ambiental: Conclusiones/Environmental Education: Conclusions

Miércoles /Wednesday 12

Mesas redondas/Round tables

Sesión matutina/Morning session

Salón Michoacán I

Manejo de recursos y biodiversidad/Resource Management and Biodiversity

David Gauthier (Canada)
Canadian Plains Research Center

Xavier Madrigal Sánchez (México)
Coordinador del Herbario de la Facultad de Biología,
Universidad Michoacana de San Nicolás de Hidalgo

Pascual Sigala (México)
Representativo del Sector Campesino

Jorge Soberón (México)
Presidente de la Comisión Nacional de Biodiversidad

Bill Calvert (USA)
University of Florida

Kingston Leong (USA)
California Polytechnic State University

Matt Wagner (USA)
Texas Parks & Wildlife

Conferencia magistral / Keynote Lecture

Carlos Toledo Manzur (México)
Director general de Programas Regionales de la Semarnap
Estrategia integral para el desarrollo sustentable de la región de la mariposa monarca

Sesión vespertina/Afternoon session

Salón Michoacán I

Participación social y desarrollo sustentable/Social Participation and Sustainable Development

Silvano Aureoles Conejo (México)
Red MOCAF

Carlos Toledo Manzur (México)
Programas Regionales de la Semarnap

Mia Monroe (USA)
US National Park Service

Melida Tajkbakhsh (USA)
US Fish & Wildlife Service

Desarrollo sustentable y conservación/Sustainable Development and Conservation

Robert Aiken (Canada)
University of Concordia

Homero Gómez González (México)
Representante del Sector Campesino

Víctor Manuel Toledo Manzur (México)
Instituto de Ecología, UNAM

Leticia Merino (México)
Centro Regional de Investigaciones Multidisciplinarias, UNAM

David Bray (USA)
Florida International University

Cierre de la sesión/End of Session

Jueves /Thursday 13

Mesas redondas/Round tables

Sesión matutina/Morning session

Salón Michoacán I

Prioridades de Investigación/Research Priorities

Phil Schappert (Canada)
York University

Alfonso Alonso Mejía (México)
Smithsonian Institute

Roberto de la Maza Elvira (México)
Instituto Nacional de Ecología

Manuel Sánchez (México)
Ejido La Mesa

Dennis Frey (USA)
California Polytechnic State University

Steve Malcolm (USA)
Western Michigan University

Karen Oberhauser (USA)
University Of Minnesota

Conferencia magistral/Keynote Lecture

David Gauthier (Canada)
Canadian Plains Research Center
-*Ecosystem Sustainability*

Sesión vespertina/Afternoon session

Salón Michoacán I

Políticas y legislación/Policies and Laws

Steve Wendt (Canada)
Canadian Wildlife Service, Environment Canada

Pedro Álvarez-Icaza Longoria (México)
Dirección General de Ordenamiento Ecológico e Impacto Ambiental, INE

Jesús Manuel de Jesús (México)
Felipe de los Alzati, Zitácuaro, Michoacán

Roberto Solís Calderón (México)
Reserva Especial de la Biosfera Mariposa Monarca, INE

Brooks Yeager (USA)
U.S. Department of the Interior

Estrategias de comunicación y divulgación/Communication and Outreach

Donald Davis (Canada)
The friends of Presqu'île Park

Jean Lauriault (Canada)
Canadian Museum of Nature

Luis Felipe Crespo Oviedo (México)
Reserva Especial de la Biosfera Mariposa Monarca, INE

Francisco García (México)
Comisario edjidal de San Francisco de los Reyes de Michoacán

Oscar Montero (México)
Unidad de Televisión Educativa, SEP

Elizabeth Donnelly (USA)
Journey North

Orley Taylor (USA)
University of Kansas

Cierre de la sesión/End of Session

Viernes /Friday 14

Mesas redondas/Round tables

Sesión matutina/Morning session

Salón Michoacán I

Sesión pública: Presentación de los resultados de cada mesa redonda/
Public Session: Presentation of Round tables'conclusions

Manejo de recursos y biodiversidad/Resource management and biodiversity

Participación social y desarrollo sustentable/Social participation and Sustainable Development

Desarrollo sustentable y conservación/Sustainable Development and Conservation

Políticas y leyes/Policies and Laws

Prioridades de investigación/Research Priorities

Estrategias de comunicación/Communication and Outreach

Sesión vespertina/Afternoon session

Salón Michoacán I

Ceremonia de clausura de la reunión regional sobre la mariposa monarca/
Closing ceremonies of the North American conference on the monarch butterfly

Presentación/Presentation

John Rogers (USA)
Subdirector, Fish and Wildlife Service

Karen Kraft Sloan (Canada)
Parliamentary Secretary, Environment Canada

Julia Carabias Lillo (México)
Secretaria, Secretaría de Medio Ambiente, Recursos Naturales y Pesca de México

Ceremonia de clausura/Closing
Comida de despedida/Farewell Lunch

Decreto presidencial
Presidential Decree

Decreto presidencial[1]

(Versión abreviada)
Secretaría de Desarrollo Urbano y Ecología

10-09-86 DECRETO por el que por razones de orden público e interés social, se declaran áreas naturales protegidas para los fines de la migración, invernación y reproducción de la mariposa monarca, así como la conservación de sus condiciones ambientales, la superficie de 16,110-14-50 hectáreas, ubicadas en los municipios que se indican, pertenecientes a los estados de Michoacán y de México.

Al margen un sello con el Escudo Nacional, que dice: Estados Unidos Mexicanos.–Secretaría de Desarrollo Urbano y Ecología.

MIGUEL DE LA MADRID H., PRESIDENTE CONSTlTUClONAL DE LOS ESTADOS UNIDOS MEXICANOS, EN EJERCICIO DE LA FACULTAD QUE ME CONFIERE EL ARTICULO 89 FRACCION I DE LA CONSTITUCION POLITICA DE LOS ESTADOS UNIDOS MEXICANOS… FRACCION I, DE LA LEY ORGANICA DE LA ADMINISTRACION PUBLICA FEDERAL: Y

CONSIDERANDO

Que por Decreto del Ejecutivo Federal de 30 de mayo de 1983, publicado en el Diario Oficial de la Federación del 31 del mismo mes y año, se aprobó el Plan Nacional de Desarrollo 1983-1988 que señala los lineamientos de estrategia en materia de ecología, considerando prioritario establecer medidas preventivas que regulen el aprovechamiento integral y racional de los recursos naturales renovables, así como realizar acciones orientadas a la conservación y enriquecimiento de dichos recursos que forman parte del patrimonio de la Nación.

Que el citado Plan Nacional de Desarrollo tiene entre sus objetivos el promover la conservación de los ecosistemas representativos de las diversas regiones del país, cuya fragilidad las hace susceptibles de alteración por las actividades humanas, conservar sus bellezas naturales; normar y racionalizar las actividades productivas; y realizar investigaciones básicas y aplicadas primordialmente en el campo de la ecología y en el manejo de los recursos naturales.

Que por decreto del Ejecutivo Federal de 21 de agosto de 1984, publicado en el Diario Oficial de la Federación del 26 de septiembre del mismo año, en cumplimiento del Plan Nacional de Desarrollo, se aprobó el Programa Nacional de Ecología 1984-1988, el que entre sus proyectos estratégicos incluye el relativo al Sistema Nacional de Áreas Naturales Protegidas para conservar, preservar y dar a conocer los recursos naturales del país con potencial de uso, en apoyo al desarrollo socioeconómico de la población, así como regular su aprovechamiento racional e integral.

Que dicho Programa establece entre sus lineamientos de estrategia, la realización de acciones tendientes a la conservación y enriquecimiento de los recursos naturales de las áreas protegidas, mediante programas de recuperación y preservación de las especies como es el caso de la mariposa monarca.

Que los lineamientos de política más importantes del Ejecutivo a mi cargo en el manejo de las áreas naturales protegidas son entre otros los de: preservar la diversidad y el equilibrio ecológico del conjunto de especies animales y vegetales, particularmente las raras, de especial belleza, endémicas, amenazadas o en peligro de extinción, dentro de sus ecosistemas naturales; salvaguardar genéticamente la diversidad evolutiva de las especies y constituir las áreas protegidas en centros de investigación.

Que mediante Decreto del Ejecutivo Federal de 25 de marzo de 1980, publicado en el Diario Oficial de la Federación del 9 de abril del mismo año, por causa de utilidad pública, se estableció como zona de reserva y refugio de la fauna silvestre los lugares donde la mariposa conocida con el nombre de «monarca», migra, invierna y se reproduce, y asimismo se decretó en todo el territorio nacional la veda por tiempo indefinido de su caza y captura y se prohibió el aprovechamiento y utilización de sus productos y despojos.

[1] Dado que el Decreto Presidencial de 1986, establecido por el Gobierno de México para proteger el habitat de invernación de las monarca, ha sido un componente clave en los esfuerzos de conservación, los editores consideraron útil incluir el siguiente texto resumido.

Que la Secretaría de Desarrollo Urbano y Ecología, en coordinación con la Secretaría de Agricultura y Recursos Hidráulicos, realizó los estudios e investigaciones sobre las áreas que requieren la protección, mejoramiento, conservación y restauración de las condiciones ambientales que son propicias para la migración, invernación y reproducción de la mariposa monarca, y propusieron al Ejecutivo a mi cargo expida un decreto que declare la localización, extensión y características de las áreas que deben ser protegidas precisamente porque en ellas migra, invierna y se reproduce la mencionada mariposa.

Que conforme a los estudios e investigaciones a que se refiere el considerando anterior, las áreas conocidas como Sierra Chincua, Sierra El Campanario, Cerros Huacal, Chivatí, Pelón y Altamirano, ubicadas en los municipios de Ocampo, Angangueo, Zitácuaro y Contepec, en el estado de Michoacán, y Donato Guerra, Villa de Allende y Temascalcingo, en el estado de México, son los principales lugares donde el lepidóptero conocido con el nombre de «monarca», migra, invierna y se reproduce, y que dichas áreas contienen además especies animales y vegetales de importancia, requiriéndose por lo anterior su conservación y aprovechamiento racional.

Que en esas áreas podrían distinguirse las zonas núcleo y las zonas de amortiguamiento. Las primeras son territorios que constituyen el hábitat indispensable para la permanencia del fenómeno migratorio de la mariposa monarca y el banco genético de las diversas especies que ahí habitan, y en donde las únicas actividades permitidas deben ser las de investigación, por lo que corresponde decretar la veda total e indefinida de la explotación forestal y de aprovechamiento de la flora en general y de la fauna silvestre. Las segundas son aquellas que se destinan a proteger a las zonas núcleo del impacto exterior y en donde se pueden realizar actividades económicamente productivas, dentro de normas ecológicas encaminadas a la protección del ambiente en que ocurra el fenómeno migratorio de la mariposa monarca, acordes con los resultados de investigaciones relativas al uso racional y sostenido de los recursos naturales, en estas últimas zonas, las vedas de aprovechamiento forestal y cinegético tendrán carácter temporal.

Que los estudios e investigaciones a que se refieren los párrafos precedentes y la consecuente declaración de las áreas naturales protegidas en que migra, invierna y se reproduce la mariposa monarca, son del conocimiento y han merecido la aprobación de los gobiernos de los estados de México y Michoacán, así como de los municipios de Donato Guerra, Villa de Allende y Temascalcingo en el estado de México y de Ocampo, Angangueo, Zitácuaro y Contepec en el estado de Michoacán.

Que de los estudios e investigaciones a que se refiere el Considerando Séptimo, se determinó que para declarar las áreas que deben ser protegidas porque en ellas migra, invierna y se reproduce la mariposa monarca, se requiere una superficie total de 16,110-14-50 Ha, integrada por zonas núcleo con una superficie de 4,490-61-00 Ha, y zonas de amortiguamiento con una superficie de 11,619-53-50 Ha, siendo su descripción topográfica analítica la siguiente:

(Nota del editor: los datos topográficos de los polígonos pueden ser consultados en el documento original)

Que el Ejecutivo Federal está facultado legalmente para expedir el presente Decreto que declara la localización, extensión y características de las áreas naturales protegidas, para los fines de la migración, invernación y reproducción de la mariposa monarca, así como la conservación de sus condiciones ambientales.

Por lo anteriormente expuesto, he tenido a bien expedir el siguiente:

DECRETO

ARTICULO PRIMERO.– Por razones de orden público e interés social, se declaran áreas naturales protegidas para los fines de la migración, invernación y reproducción de la monarca, así como la conservación de sus condiciones ambientales, la superficie de 16,110-14-50 Ha, ubicadas en los municipios de Ocampo, Angangueo, Zitácuaro y Contepec del estado de Michoacán y en los municipios de Donato Guerra, Villa de Allende y Temascalcingo del estado de México, cuya descripción topográfica-analítica se especifica en el presente ordenamiento.

Dentro de las mencionadas áreas naturales protegidas se establecen como zonas núcleo las superficies de 1060-01-50 Ha, 900-58-00 Ha, 940-24-00 Ha, 657-70-62.5 Ha, 687-43-37.5 Ha y 244-63-50 Ha, y como zonas de amortiguamiento las superficies de 1635-86-50 Ha, 988-88-50 Ha, 1074-38-00 Ha, 6787-33-50 Ha y 1133-07-00 Ha, cuyos límites han quedado precisados en los considerandos de este Decreto, y que se tienen aquí por reproducidos como si se insertasen a la letra.

ARTICULO SEGUNDO.– El ejercicio de las acciones para el acondicionamiento, conservación, desarrollo y vigilancia de las áreas naturales protegidas para los fines de la migración, invernación y reproducción de la mariposa monarca queda a cargo de la Secretaría de Desarrollo Urbano y Ecología, la que podrá celebrar convenios y acuerdos de coordinación con otras dependencias u organismos federales, con los gobiernos de los estados de México y Michoacán y con los municipios de Ocampo, Angangueo, Zitácuaro, Contepec, Donato Guerra, Villa de Allende y Temascalcingo, y de concertación e inducción con los sectores social y privado, los cuales versarán sobre:

1. La coincidencia de las políticas y los programas federales de ecología con los de los estados y municipios, así como la forma en que éstos participarán en la realización de los fines que son materia del presente Decreto.
2. La ejecución del Programa Integral de Desarrollo de las áreas naturales protegidas por este Decreto.
3. La aplicación de recursos financieros destinados a la realización del programa a que se refiere el punto anterior.

ARTICULO TERCERO.– El Programa Integral de Desarrollo de las áreas naturales protegidas para los fines de la migración, invernación y reproducción de la mariposa monarca deberá contener, cuando menos:

I. La descripción y análisis de sus características físicas, sociales, biológicas y culturales;
II. Las acciones a realizar dentro del marco del Sistema Nacional de Planeación Democrática; y
III. Las normas técnicas aplicables al desarrollo y manejo de las áreas naturales protegidas por este Decreto.

ARTICULO CUARTO.– La Secretaría de Desarrollo Urbano y Ecología no autorizará la ejecución de obras públicas o privadas dentro de las zonas núcleo de las áreas naturales protegidas para los fines de migración, invernación y reproducción de la mariposa monarca, cuando en cualquier forma puedan afectar los propósitos de este Decreto.

Los proyectos de obras públicas o privadas que pretendan realizarse dentro de las áreas consideradas como zonas de amortiguamiento y que puedan producir deterioro ambiental, deberán ser presentados a la Secretaría de Desarrollo Urbano y Ecología, para su estudio y en su caso para su aprobación, modificación o rechazo. En ningún supuesto se autorizarán los proyectos de obra que afecten las condiciones mínimas indispensables para la migración, invernación y reproducción de la mariposa monarca.

ARTICULO QUINTO.– Las dependencias y entidades de la Administración Pública Federal que ejerzan acciones o inversiones en las áreas de que trata este Decreto, se ajustarán a sus disposiciones, y la Secretaría de Programación y Presupuesto no autorizará partida presupuestal destinada a programas o actividades que lo contravengan.

ARTICULO SEXTO.– Las dependencias y entidades de la Administración Pública Federal que por su competencia deban desarrollar acciones en las áreas naturales protegidas, lo harán en congruencia con los fines y propósitos de este Decreto.

ARTICULO SEPTIMO.– La Secretaría de Desarrollo Urbano y Ecología tomará las medidas necesarias para evitar que agentes o factores contaminantes afecten el hábitat de la mariposa monarca, y establecerá los criterios que normarán la investigación técnica y científica en las áreas que son materia de protección.

ARTICULO OCTAVO.– Se decreta veda total e indefinida de la explotación forestal y del aprovechamiento de la flora silvestre en las zonas núcleo.

ARTICULO NOVENO.– Se declara zona de reserva y refugio de la mariposa monarca y se decreta veda total e indefinida de la fauna silvestre en las zonas núcleo.

ARTICULO DECIMO.– Se establece en todo el territorio nacional veda total e indefinida para la caza y captura de la mariposa monarca.

ARTICULO DECIMO PRIMERO.– En las zonas de amortiguamiento, se decretarán las vedas temporales de aprovechamiento forestal, de la flora en general y de la fauna silvestre, necesarias para asegurar eficazmente la protección de los suelos, las cuencas de captación, los regímenes hidrológicos y en general la conservación de los recursos naturales referidos a la protección de la migración, invernación y reproducción de la mariposa monarca.

ARTICULO DECIMO SEGUNDO.– El aprovechamiento de las aguas en la totalidad de las áreas que son objeto de esta declaratoria, se restringirá a las necesidades domésticas y de riego agrícola que requieran los habitantes de la región.

Presidential decree[1]

Diario Oficial
Thursday 9th of October, 1986
Ministry of Urban Development and Ecology (SEDUE)

Decree that for reasons of social interest and public order, 16,110–14–50 ha, located in the indicated municipalities, belonging to the States of Mexico and Michoacán, are declared protected natural areas for the purpose of migration, overwintering and reproduction of the monarch butterfly, together with the conservation of its environmental conditions.

MIGUEL DE LA MADRID H., CONSTITUTIONAL PRESIDENT OF THE UNITED STATES OF MEXICO IN THE EXERCISE OF THE FACULTY BESTOWED ON ME BY THE ARTICLE 39 OF THE POLITICAL CONSTITUTION OF THE UNITED STATES OF MEXICO, ...(a listing of the law numbers pertaining to the Mexican law follows and can be found in the original decree, p. 33) ..., AND FRACTION I OF THE ORGANIC LAW OF THE FEDERAL PUBLIC ADMINISTRATION; AND

CONSIDERING

Whereas by the decree of the Federal Executive dated 30th of May of 1983, published in the *Diario Oficial* of the Federation the 31st of the same month and year, the National Plan of Development 1983–1988 was approved, which indicates the guidelines in the area of ecology, considering a priority to establish preventive measures to regulate the integral and rational use of the renewable natural resources, and to carry out actions leading towards the conservation and enrichment of the fore mentioned resources which belong to the Heritage of the nation.

Whereas the fore mentioned National Plan of Development has among its objectives: to promote the conservation of the representative ecosystems of the diverse regions throughout the country, the fragility of which makes them prone to disturbance due to human activities; to conserve its natural beauties; to lay down rules and rationalise the productive activities; and to carry out basic and applied research primarily in the field of ecology and in the management of natural resources.

Whereas by the decree of the Federal Executive dated 21st of August of 1984, published in the *Diario Oficial* of the Federation the 26th of September of the same year, in fulfilment of the National Plan of Development 1983–1988, the National Program of Ecology 1984–1988 was approved, and includes the relative to the National System of Protected Natural Areas for the conservation, preservation and display of the natural resources of the country with potential use, in support of the socio-economic development of the population, and for the regulation of their integral and rational use.

Whereas such a Program establishes among its strategy guidelines the carrying-out of actions leading towards the conservation and enrichment of the natural resources of the protected areas, through programs of species recovery and preservation, as is the case with the “monarch” butterfly.

Whereas the more important Executive policy guidelines under my custody in the management of the protected natural areas are among other: to preserve the diversity and ecological equilibrium of both animal and plant species, particularly the rare ones, the especially beautiful, the endemic, threatened or in danger of extinction, within their natural ecosystems; to safeguard genetically the evolutionary species diversity and constitute the protected areas into centers for research.

Whereas through the decree of the Federal Executive dated 25th of March of 1980, published in the *Diario Oficial* of the Federation the 9th of April of the same year, for reasons of public benefit, it was established as a zone of wildlife reserve and shelter the areas where the butterfly known with the name of “monarch”, migrates, overwinters, and reproduces, in the same way it was decreed for all the national territory and for indefinite time a hunting and capture ban, including the use of its products and wastes.

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[1] Given that the presidential decree of 1986, established by the Mexican government to protect the habitat of overwintering monarchs, has been a key component for conservation efforts, the editors deemed it useful to include the following abbreviated text.

Whereas the Ministry of Urban Development and Ecology (SEDUE), in coordination with the Ministry of Agriculture and Water Resources (SARH), carried out the studies and research on the areas required for the protection, improvement, conservation and restoration of the environmental conditions favourable for the migration, overwintering and reproduction of the “monarch”, and proposed to the Executive under my responsibility to issue a decree which declares the location, size and characteristics of the areas that need to be protected precisely because the fore mentioned butterfly migrates, overwinters and reproduces in those areas.

Whereas according to the studies and research referred to in the previous statement, the areas known as Sierra Chincua, Sierra El Campanario, Cerros Huacal, Chivati, Pelon and Altamirano, located in the Municipalities of Ocampo, Angangueo, Zitacuaro and Contepec, within the State of Michoacán, and Donato Guerra, Villa de Allende and Temascalcingo, within the State of Mexico, are the main places where the butterfly known with the name of “monarca”, migrates, overwinters and reproduces, and that these areas harbour also plant and animal species of importance, hence require to be conserved and rationally used.

Whereas in those areas the core zones and buffer zones can be recognized. The former are territories which constitute the indispensable habitat for the permanence of the migratory phenomenon of the “monarch” butterfly together with the genetic pool of the diverse species which also occur there, and in which the only allowed activity is that of research, it therefore follows to decree a total and indefinite ban to the exploitation of the forest and to the use of the flora in general and of the wildlife. The second are those designed to protect the core zones from outside impacts, and in which productive economic activities may be carried out, within the ecological norms geared towards the protection of the environment in which the migratory phenomenon of the “monarch” butterfly takes place, in accordance with the results of the research pertaining to the rational and sustainable use of the natural resources, in this latter zones, the ban set upon the use of the forest and wildlife will be of temporary nature.

Whereas the studies and research referred to in the fore mentioned paragraphs and the following declaration of the protected natural areas in which the “monarch” butterfly migrates, overwinters and reproduces, are of the knowledge of and have deserved the approval from the governments of the States of Mexico and Michoacán, and of the municipalities of Donato Guerra, Villa de Allende and Temascalcingo within the State of Mexico and Ocampo, Angangueo, Zitacuaro and Contepec within the State of Michoacán.

Whereas from the studies and research referred earlier in the seventh statement, it was determined that in order to declare the areas that need to be protected because the “monarch” butterfly migrates, overwinters and reproduces in them, it is necessary a total surface of 16,110–14–50 ha; composed by the core zones with a surface of 4,490–61–00 ha, and buffer zones with a surface of 11,619–53–50 ha, being the analytic topographical description as follows:

> (Note of translator: the detailed description by coordinates of the polygons involving the core and buffer zones for each and all five reserves was omitted here for the sake of parsimony, please refer to the original document.)

Whereas the Federal Executive has the legal faculties to issue this Decree which declares the location, size and characteristics of the protected natural areas, for the purposes of the migration, overwintering and reproduction of the “monarch” butterfly together with the conservation of its environmental conditions.

Given the above mentioned, I have decided to issue the following:

DECREE

FIRST ARTICLE.- For reasons of public order and social interest, 16,110-14-50 ha of natural areas, located in the Municipalities of Ocampo, Angangueo, Zitacuaro, and Contepec within the State of Michoacan and in the Municipalities of Donato Guerra, Villa de Allende and Temascalcingo within the State of Mexico, whose analytical topographic descriptions are specified in this ordinance, are declared protected for the migration, overwintering and reproduction of the "Monarch" butterfly, together with the conservation of its environmental conditions.

Within the above mentioned protected natural areas, the following surfaces are established as core zones: 1060-01-50 ha; 900-58-00 ha; 940-24-00 h;, 657-70-62.5 ha and 687-43-37.5 ha; and 244-63-50 ha; and as buffer zones: 1635-86-50 ha, 988-88-50 ha, 1074-38-00 ha, 6787-33-50 ha and 1133-07-00 ha, the limits of which have been specified in the statements of this Decree.

Note of translator: The figures offered above correspond to Chincua, Campanario, Chivatí-Huacal, Pelón (with two core areas), and Altamirano, respectively.

SECOND ARTICLE.- The exercise of the actions conducive to condition, conserve, develop and the surveillance of the protected natural areas for the migration, overwintering and reproduction of the "monarch" butterfly is under the responsibility of the Ministry of Urban Development and Ecology (SEDUE), which may establish agreements of coordination with other dependencies or federal entities, with the Governments of the States of Mexico and Michoacán and with the Municipalities of Ocampo, Angangueo, Zitacuaro, Contepec, Donato Guerra, Villa de Allende and Temascalcingo, and of orchestration and persuasion with the social and private sectors, which will deal with:

1.- The agreement of the ecology programs and policies of the federal government with those pertaining to the States and Municipalities, and the way in which the latter will participate in the carrying out of the aims concerning this decree.

2.- The carrying out of the Integral Program of Development for the natural areas protected by this Decree.

3.- The assignment of financial resources in order to carry out the program mentioned in the previous item.

THIRD ARTICLE.- The Integral Program of Development for the natural areas protected for the migration, overwintering and reproduction of the "monarch" butterfly, will have to include at least:

I.- The description and analysis of their physical, social biological and cultural characteristics;

II.- The actions to be carried out within the framework of the National System of Democratic Planning; and

III.- The technical norms applicable for the development and management of the natural areas protected by this Decree.

FOURTH ARTICLE.- The Ministry of Urban Development and Ecology (SEDUE) shall not authorize the carrying out of public or private works within the core zones of the natural areas protected for the migration, overwintering and reproduction of the "monarch" butterfly, if they could affect at any time the purposes of this Decree.

The projects for public or private works aimed to be carried out within the areas considered as buffer zones and which may lead to environmental damage, shall be presented to the Ministry of Urban Development and Ecology for its study, and if necessary for their approval, modification or rejection. Under no circumstances any work project will be authorized if it affects the minimum conditions required for the migration, overwintering and reproduction of the "monarch" butterfly.

FIFTH ARTICLE.- The Federal Public Dependencies and Entities which may exercise actions or investments in the areas considered by this Decree, will have to follow its provisions, and the Ministry of Finance (SPP) shall not authorize any budget aimed for programs or activities which may infringe it.

SIXTH ARTICLE.- The Federal Public Dependencies and Entities which because of their capacity have to develop actions in the protected natural areas, will do this in accordance with the aims and purposes of this Decree.

SEVENTH ARTICLE.- The Ministry of Urban Development and Ecology will take the necessary provisions to avoid that polluting agents or factors affect the "habitat" of the "monarch" butterfly, and will establish the criteria which will lay down the rules for the scientific and technical research in the areas subject to protection.

EIGHTH ARTICLE.- It is hereby decreed a total and indefinite ban concerning the exploitation of the forest and the use of the wild plants at the core zones.

NINTH ARTICLE.- It is hereby declared the zone of reserve and refuge for the “monarch” butterfly, and a total and indefinite ban to the use and exploitation of wildlife in the core zones.

TENTH ARTICLE.- It is hereby established for all the national territory a total and indefinite ban concerning the hunting and capture of the “monarch” butterfly.

ELEVENTH ARTICLE.- In the buffer zones, a temporary ban will be established for the use of the forest, the flora in general and of the wildlife, this being necessary to ensure the effective protection of the land, the watersheds, the water cycles and in general the conservation of the above mentioned natural resources related to the protection of the migration, overwintering and reproduction of the “monarch” butterfly.

TWELFTH ARTICLE.- The use of water in the totality of the areas affected by this decree will be limited for domestic use and for agricultural irrigation schemes that shall be required by the inhabitants of the region.