What influences the pattern of pollutant releases in Ontario, Canada?

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Origin of the Environmental Justice Movement

- In August 1978, Ward Transformers Company dumped 115 tons of liters of PCB-contaminated transformer oil along 240 miles of roads in North Carolina.
- The State of North Carolina $\rightarrow$ build a landfill to deposit the contaminated soil (6000 truckloads).

- Proposed location: Afton, a rural town in Warren County that was 75% African American, with no mayor/city council, among the poorest (ranked 97th out of 100 counties) in NC.

Origin of the Environmental Justice Movement

Public Response to Landfill:

- Local leaders organized protests, support from civil rights groups across the nation.
- 500 people were arrested during 6 weeks of marches and street protests.
- Lawsuits, public hearings and scientific studies: Compromise reached in 1982, the State promised to “not expand” the landfill.

Environmental Justice Literature

Evidence of environmental inequity:

- Siting of hazardous waste sites:
  U.S. GAO (1983), UCC(1987), Goldman & Fitton (1994)
- Location of large industrial and waste facilities:
  Anderton et. al. (1994), Boer et. al. (1997), Wolverton (2009, 2011)
- Air pollution concentrations:
  Morello-Frosch et. al. (2001), Ash and Fetter (2004), Banzhaf et al. (2007)
- Discrimination in regulatory enforcement activities:
  Hird (1993) Lavelle and Coyle (1992)
- Review articles $\rightarrow$ Poor and minority neighborhoods have disproportionate exposure to environmental hazards. (Szasz and Meuser, 1997; Noonan, 2008; Banzhaf 2011)

Environmental Justice Literature

Different studies different results

- Hazardous waste handlers of any sort:
  For: Ringquist (1998)
  Against: Davidson & Anderton (2000)
- Facilities that produce and release toxic chemicals:
  For: Burke (1994), Setzer et. al. (1995) Sadd et. al. (1999)
  Against: Bowen et. al.(1995), Holmes, Slade & Cowart (2000)
- Reviews of the EJ literature:
  For: Mohai & Bryant (1992), Goldman (1993)
  Against: U.S. GAO (1995), Bowen(2001)

Canadian Literature on EJ

1. **Eyles, Cole & Reader (1997):** Investigate environmental equity at the county level in Ontario using 1991 Census
   - Dwelling values, income, population & manuf. employment
2. **Jerrett et. al. (2004):** Whether racial gradients exist in air pollution across Hamilton
   - Similar findings to Eyles et. al. (1997), Sensitivity to spatial autocorrelation
3. **Buzzelli and Jerrett (2010):** Exposure to traffic-related air pollution across neighbourhoods in Toronto
   - Mixed results: Neighborhoods with lone-parents, low education, low-median income, high-status occupations & high dwelling values are more exposed.
4. **Buzzelli (2008):** Development & adoption of an environmental justice policy

Research Questions

1. Is there environmental equity in Ontario, Canada?
2. Are the correlations between envrionmental hazards and nearby residential populations robust across time?
   - Last five censuses: 1996, 2001, 2006, 2001 and 2016
3. Are the observed correlations robust across altnernate distance-based GIS methods?
   - Areal Containment
   - Centroid Containment
   - Areal Proportionment

Data Sources

Our sample makes use of two distinct datasets:

1. **Census - Neighborhood characteristics (Ontario)**
   - Census years: 2016, 2011, 2006, 2001 and 1996
   - Census unit: Census Tracts (CT)
     i. ”small, relatively stable geographic areas that usually have a population between 2,500 and 8,000 persons.”
     ii. located in CMAs and CAs that have a core population of 50,000 or more.
     iii. Population: Average 4,710 [Min:5 Max:18,972]
     iv. Area: 17km^2 [Min:0.13 Max:4,154]
   - Variables considered:
     a) **Population:** Population density
     b) **Demographics:** Education, % of married, family size, % of aboriginals, % of vis. minorities, % of immigrants, commute
     c) **Housing:** Ave. dwelling values, ave. gross rent, % rented, % of new dwellings, % of dwellings with major repairs
     d) **Economic:** Household Income, prevalence of low-Income, rate of unemployment, labour force, economic region

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Data Sources

2. The National Pollutant Release Inventory (NPRI)

- "*Canada's legislated inventory of pollutant releases (to air, water & land), disposals and transfers for recycling.*"
- Owners/operators of facilities that meet certain requirements reports on an annual basis since 1993.
- Requirements:
  - Employment: $>$20k hrs in a calendar year
  - Activities: Incineration of waste, wood preservation, discharge of treated/untreated water, etc.
- Facility Information used:
  - Latitude and Longitude Coordinates
  - Level of emissions (air, ground and water)
  - Toxicity based categorization of pollutants (EPA)

Methodology: Distance-based methods

Figure 1: Polluting Facilities in Ontario, 2016

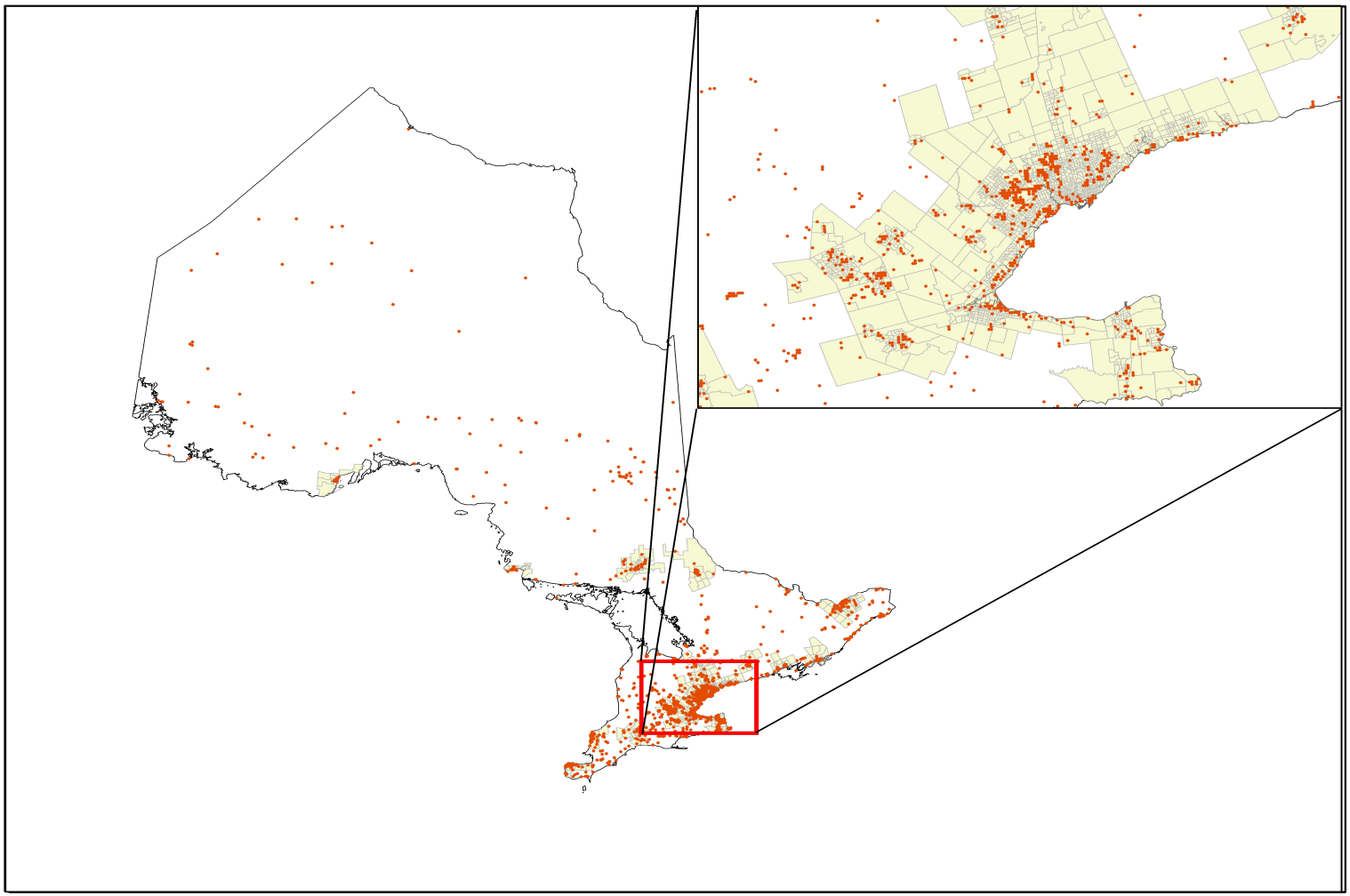

Figure 2: Raw host - Affected under AC and CC

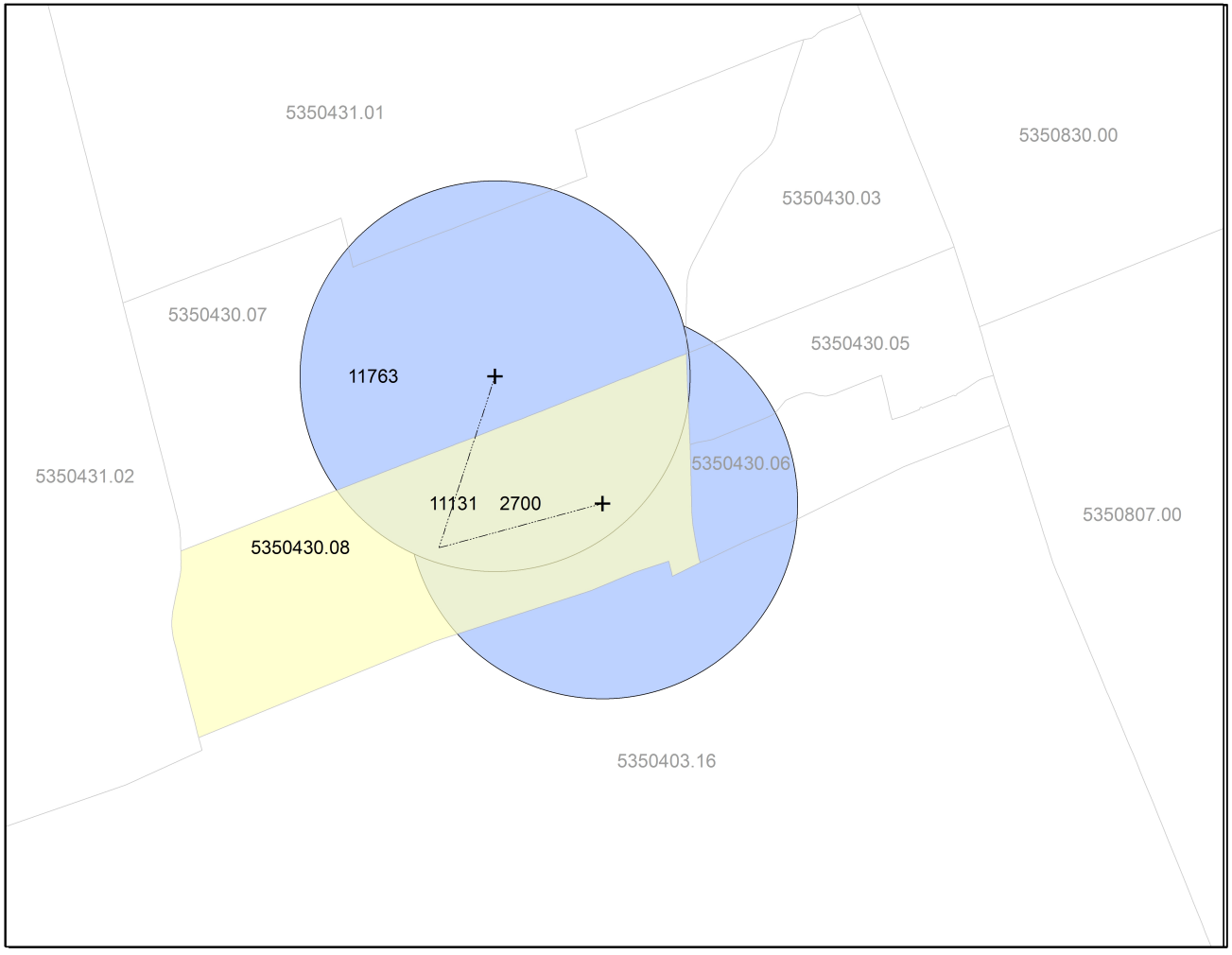

Figure 3: Raw host - Unaffected by AC and CC

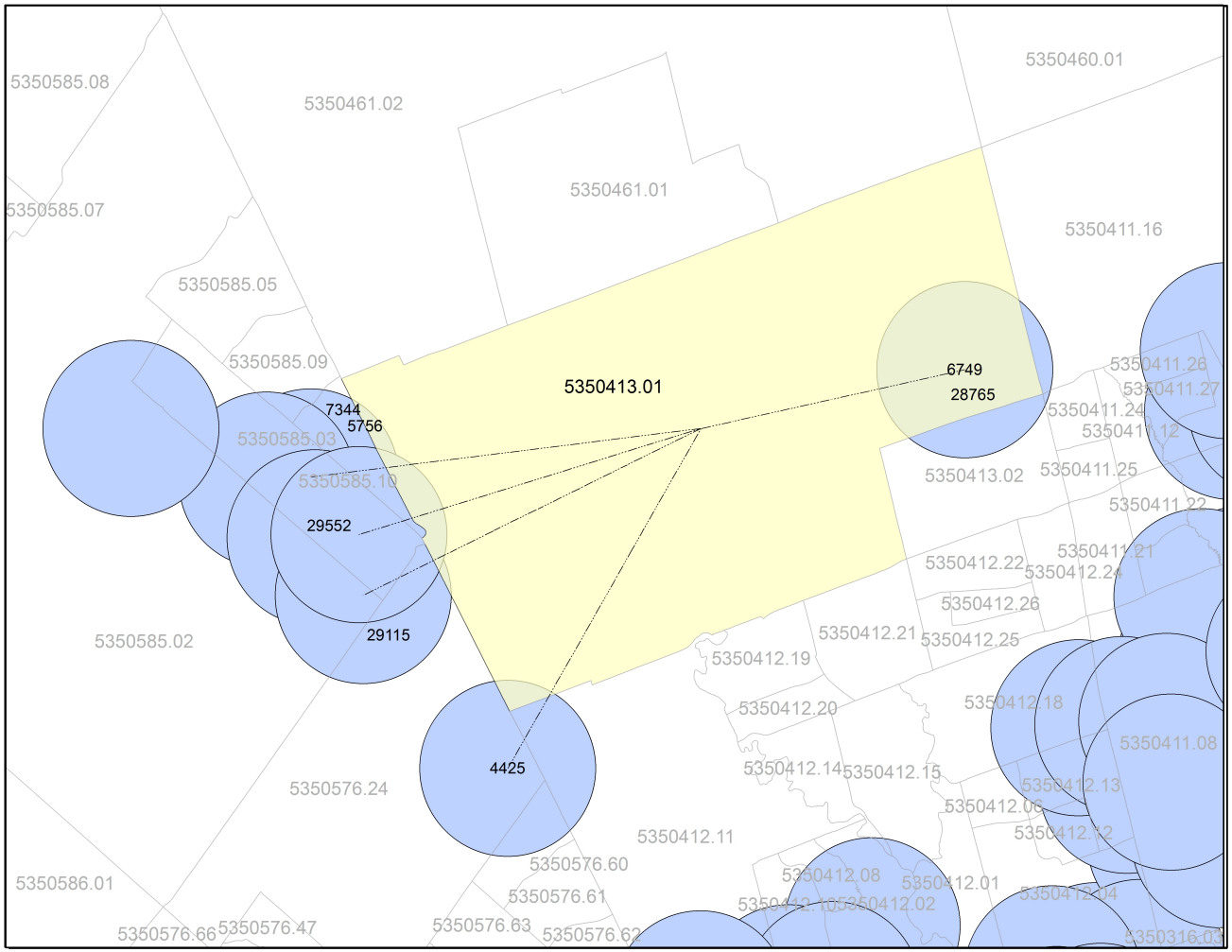

Figure 4: Non-host - Affected under AC and CC

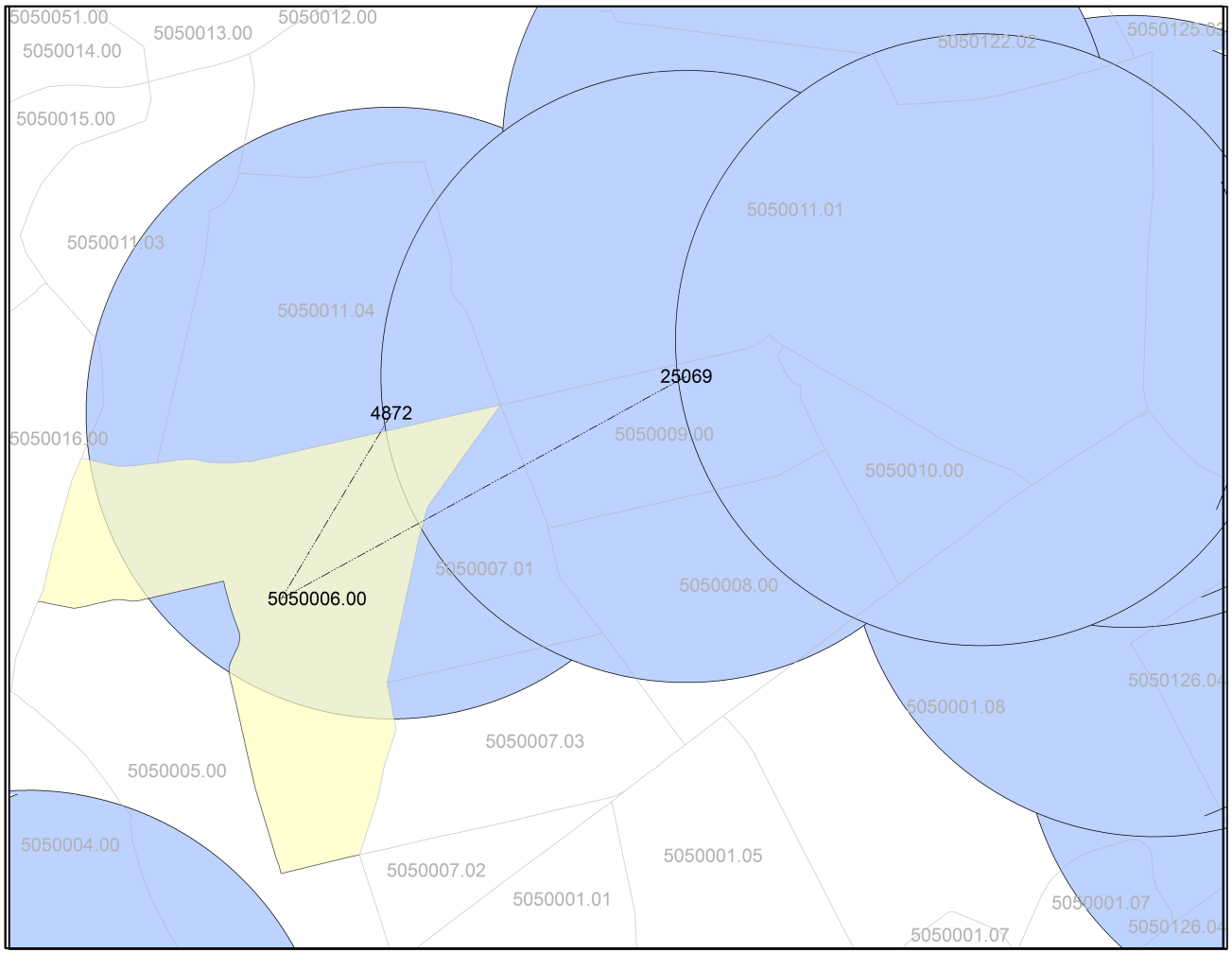

Figure 5: Illustration of AC, CC and AP

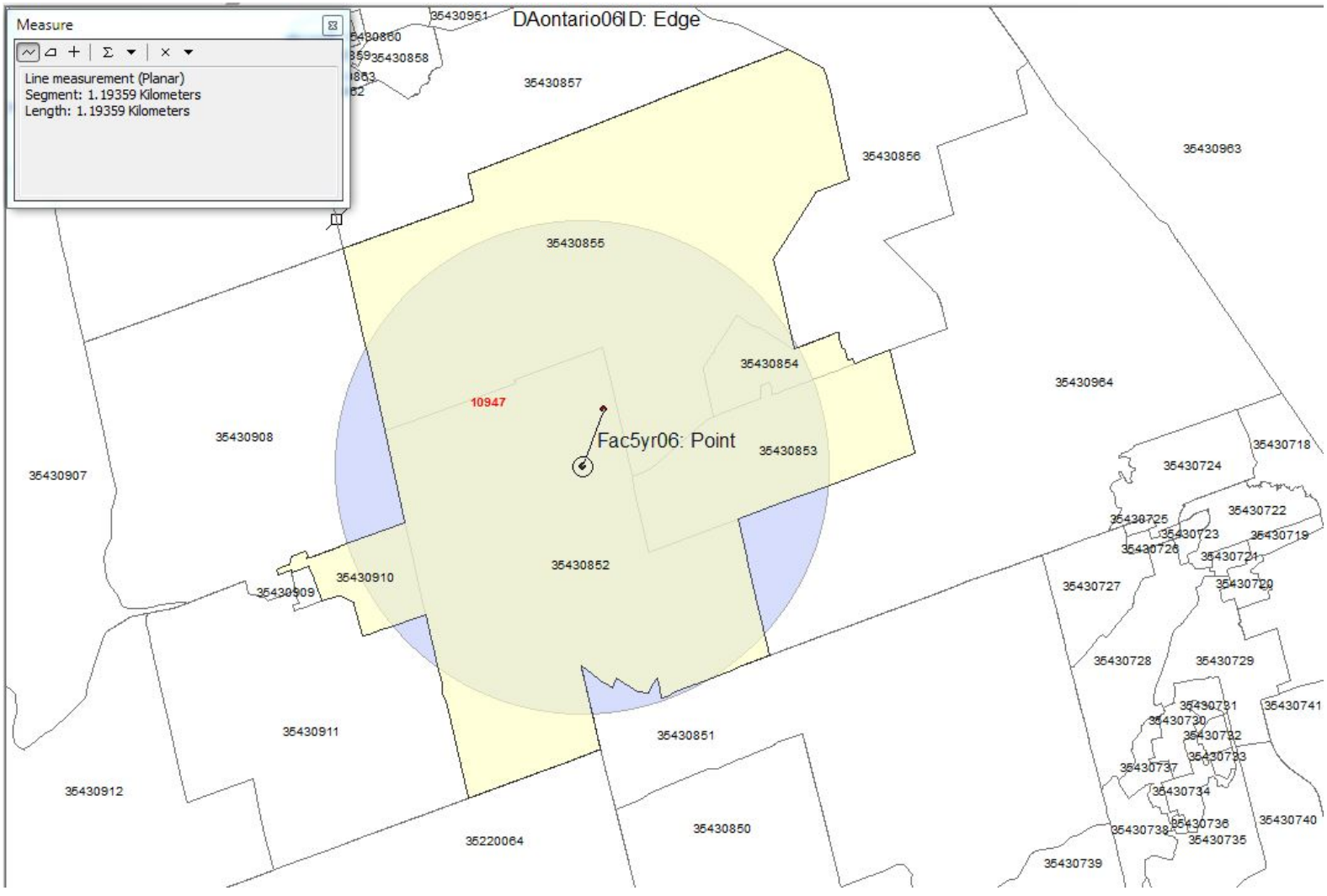

Table 1a: Summary statistics - 2016 Census

2016 Census	Raw Hosts	Non-hosts	Areal Proportionment Affected	Areal Proportionment Unaffected	Areal Containment Affected	Areal Containment Unaffected	Centroid Containment Affected	Centroid Containment Unaffected
# of Census Tracts	521	1852	1785	587	1114	1259	1103	1270
P_Married	56.5%	55.6%	44.8%	48.7%	52.4%	58.7%	52.5%	58.6%
P_Total_Imm	25.4%	32.0%	34.7%	31.2%	32.5%	28.7%	32.3%	29.0%
P_Rented	28.7%	30.4%	38.9%	26.0%	36.9%	24.0%	36.7%	24.3%
Ave_Dwel_Val	$478,730	$571,126	$515,394	$575,675	$510,386	$586,728	$509,942	$586,509
Ave_HH_Inc	$97,921	$105,188	$90,341	$110,708	$90,749	$114,914	$91,052	$114,460
Prev_li_HH_At	14.5%	15.1%	17.1%	12.6%	17.6%	12.7%	17.5%	12.8%
P_Commdur_lt30	60.7%	54.8%	55.4%	53.4%	57.2%	55.2%	57.2%	55.2%
P_Commdur_30t60	28.3%	32.3%	31.8%	33.3%	30.5%	32.2%	30.6%	32.2%
P_Comm_witcsd	59.3%	62.9%	65.0%	56.6%	66.3%	58.4%	66.5%	58.3%
P_Comm_difcsdsamecd	16.9%	12.5%	10.6%	16.1%	10.3%	16.2%	10.2%	16.2%
P_Comm_difcsdcd	23.1%	23.9%	23.8%	26.6%	22.8%	24.5%	22.6%	24.7%
P_Comm_todifpr	0.6%	0.7%	0.6%	0.8%	0.6%	0.8%	0.6%	0.8%

Table 2a: Testing for the differences in mean: Unaffected vs Affected

Variable	2016	2011	2006	2001	1996	Unaffected CTs have
CT Area	6.73***	-0.35	12.36***	8.29***	7.97***	larger surface area (km2)
Population	6.02***	5.95***	5.83***	2.44**	3.2***	more populated
P_married	18.17***	19.38***	17.43***	9.27***	8.23***	larger % of married population
Ave. Census Family	9.59***	9.43***	8.47***	3.65***	4.13***	larger census families
Ave. HH population	10.27***	9.4***	8.48***	2.94***	-2.52**	larger total population of households
P_Aboriginals	1.43	0.62	-0.09	-0.06	-1.14	
P_Vis_Min	-3.4***	-5.35***	-6.16***	-6.43***	-7.01***	smaller % of visible minorities
P_Total_Imm	-5.01***	-6.06***	-7.11***	-7.87***	-8.06***	smaller % of total immigrants
P_Rec_Imm	-4.57***	-5.14***	-6.77***	-6.34***	-7.28***	smaller % of recent immigrants
P_Educ_lt9	-8.31***	-9.68***	-9.83***	-10.75***	-10.57***	smaller % of high school dropouts
P_Educ_9t13	-3.14***	-3.17***	-3.84***	-10.81***	-10.05***	smaller % of high school graduates
P_Col_Uni	7.38***	8.57***	8.28***	10.29***	12.3***	larger % of college & university graduates
P_Rec_Const	4.02***	6.62***	8.95***	4.2***	4.57***	larger % of recently built dwellings.
P_Major_Rep	-9.59***	-7.99***	-8.84***	-6.09***	-5.73***	smaller % of dwellings that need major repairs
Gross_rent	6.22***	5.95***	5.45***	3.09***	4.45***	larger ave. gross rent
P_Rented	-14.29***	-1.9*	-14.65***	-8.38***	-7.65***	% share of rented dwellings.
Ave_Dwel_Val	5.77***	7.86***	7.95***	7.44***	7.7***	larger ave. dwelling values

than affected Census Tracts.

Table 2b: Testing for the differences in mean: Unaffected vs Affected

Variable	2016	2011	2006	2001	1996	Unaffected CTs have
Ave_HH_Inc	10.6***	13.59***	12.07***	10.87***	11.07***	larger ave. household income
Med_HH_Inc	14.71***	15.73***	15.29***	10.99***	10.61***	larger median household income
Prev_li_HH_At	-12.74***	-13.39***	-14.32***	-10.52***	-11.33***	smaller prevalence of low income (at)
P_Incdec_1	-12.66***	-12.78***	NA	NA	NA	smaller % of households in the lowest income decile
P_Incdec_2	-13.25***	-13.34***	NA	NA	NA	smaller % of households in the 2nd lowest income decile
P_Incdec_9	14.05***	13.48***	NA	NA	NA	larger % of households in the 2nd highest income decile
P_Incdec_10	9.78***	12.12***	NA	NA	NA	larger % of households in the highest income decile
Unemp_rate	-7.6***	-9.73***	-10.77***	-5.61***	-9.45***	lower rate of unemployment
P_Occ_Primary	6.88***	7.18***	11.48***	8.31***	7.19***	larger % of labour employed in primary industry
P_Occ_Manuf	-11.16***	-9.29***	-10.82***	-14.85***	-16.07***	smaller % of labour employed in manufacturing
P_Occ_Trades	-1.69*	-3.85***	-3.27***	-7.82***	-7.79***	smaller % of labour employed in trades
P_Occ_Sales	-11.16***	-11.32***	-9.71***	-7.03***	-5.92***	smaller % of labour employed in sales
P_Occ_Arts	-3.99***	-1.6	-1.94*	5.51***	4.18***	Ambiguous
P_Occ_Soc_Sci	5.56***	5.68***	3.34***	8.89***	11***	larger % of labour employed in social sciences
P_Occ_Mngmnt	10.6***	12.69***	11.11***	10.44***	9.83***	larger % of labour employed in management
P_Occ_Busi & Fin	4.4***	3.51***	2.67***	1.22	2.05**	larger % of labour employed in business admin. & finance
P_Occ_Nat_Sci	4.36***	4.61***	4.4***	5.02***	6.28***	larger % of labour employed in natural sciences
P_Occ_Health	5.93***	7.58***	8.97***	9.32***	9.28***	larger % of labour employed in health industry
P_Commdur_lt30	-2.78***	NA	NA	NA	NA	smaller % of individuals who commute lt 30 min.
P_Commdur_30t60	3.23***	NA	NA	NA	NA	larger % of individuals who commute 30t60 min.
P_Commdur_ge60	0.87	NA	NA	NA	NA	
P_Comm_witcsd	-7.53***	NA	NA	NA	NA	smaller % of commuters within the same CSD
P_Comm_difcsdsamecd	8***	NA	NA	NA	NA	larger % of commuters to a different CSD but same CD
P_Comm_difcsdcd	2.26**	NA	NA	NA	NA	larger % of commuters to a different CSD and CD
P_Comm_todifpr	3.43***	NA	NA	NA	NA	larger % of commuters to a different province
						than affected Census Tracts.

Summary of Results

Overall conclusions:

- Overall results indicate the presence of environmental inequity in Ontario, Canada. In particular, minorities and low-income groups bear a disproportionate burden of environmental hazards.
- The disparities are exacerbated, if the affected CTs are compared only to the unaffected raw-host CTs.
- Our findings are consistent with the ones found in the U.S. and Canadian literature.
- The observed correlations are robust across time and the alternate distance-based methods adopted.
- We find that the distance-based methods considered do a better job in capturing the proximity between the affected populations and the environmental hazards.

Areas of Improvement

Information on the following areas could further improve the NPRI as a dataset:

- Year of Establishment
- Facility specific information to track exit or entry