Do Water Provision Contracts with Neighbouring Communities Reduce Drinking Water Risk on Canadian Reserves?

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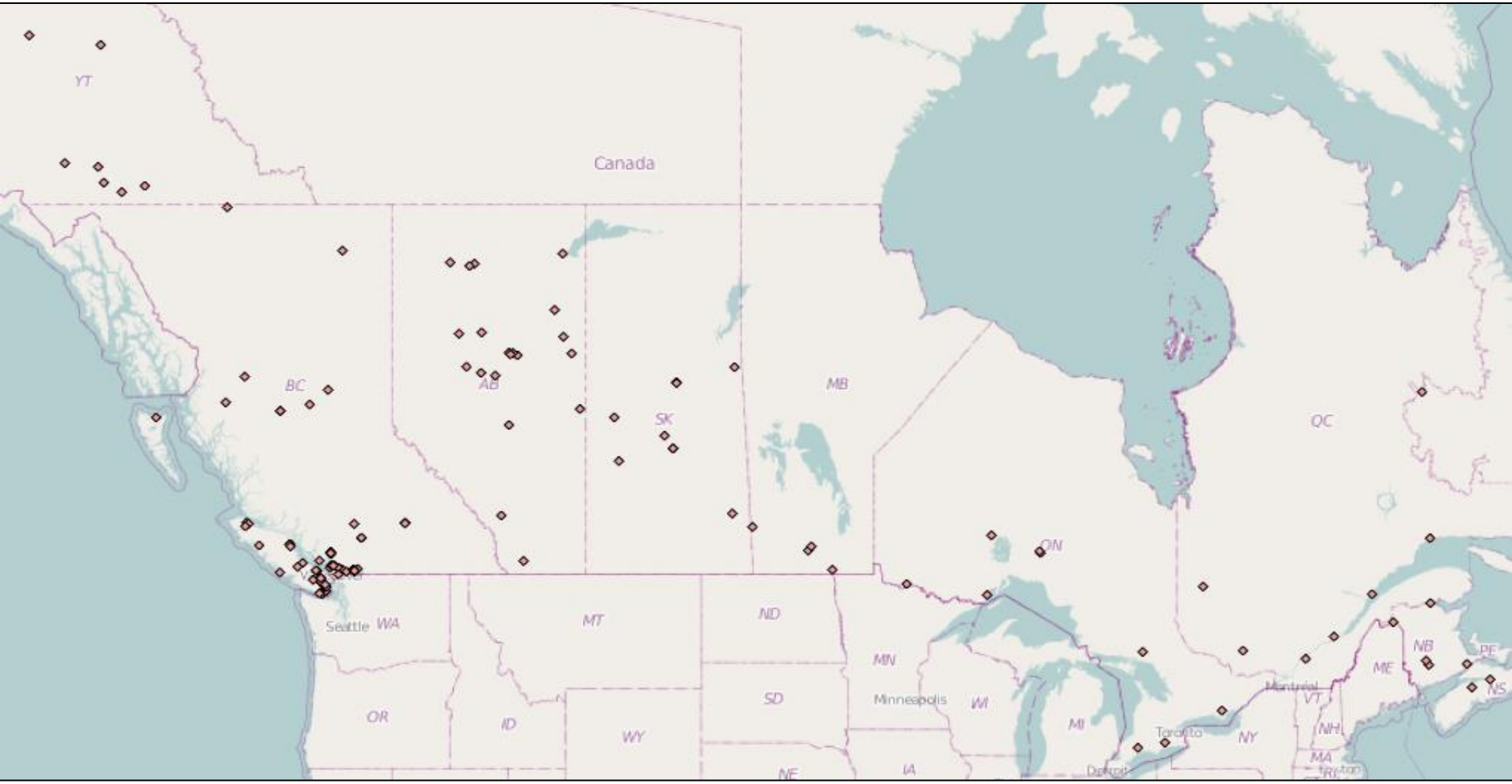
Two Key Questions

- What factors influence First Nations' decisions to participate in MTAs?
  - Geographic remoteness (-)
  - Population (-), Population density (+)
- Do MTAs reduce boil water advisories on reserves?
  - Guidelines vs. Regulations

Figure 1: Locations of First Nation Reserves with Municipal Type Agreements (MTAs) for Drinking Water Provision



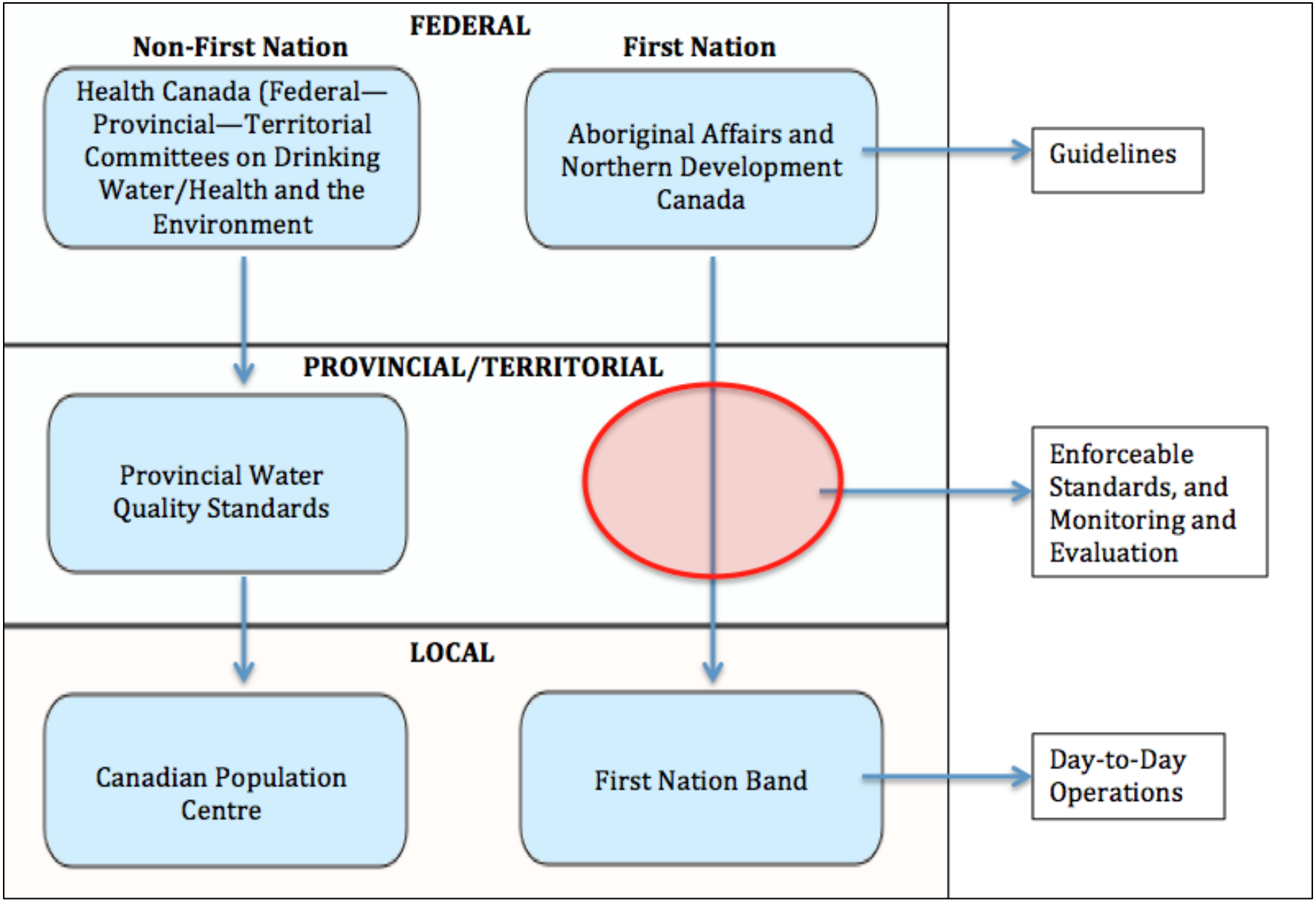
Motivation for Participation Decision

- Costs of centralized water provision
  - Economies of scale in water treatment
    - High initial fixed cost, relative to low variable costs
  - Diseconomies of scale in water distribution
    - Low initial fixed costs, relative to high variable costs(infrastructure and energy costs increase per length of pipe/number of connections)

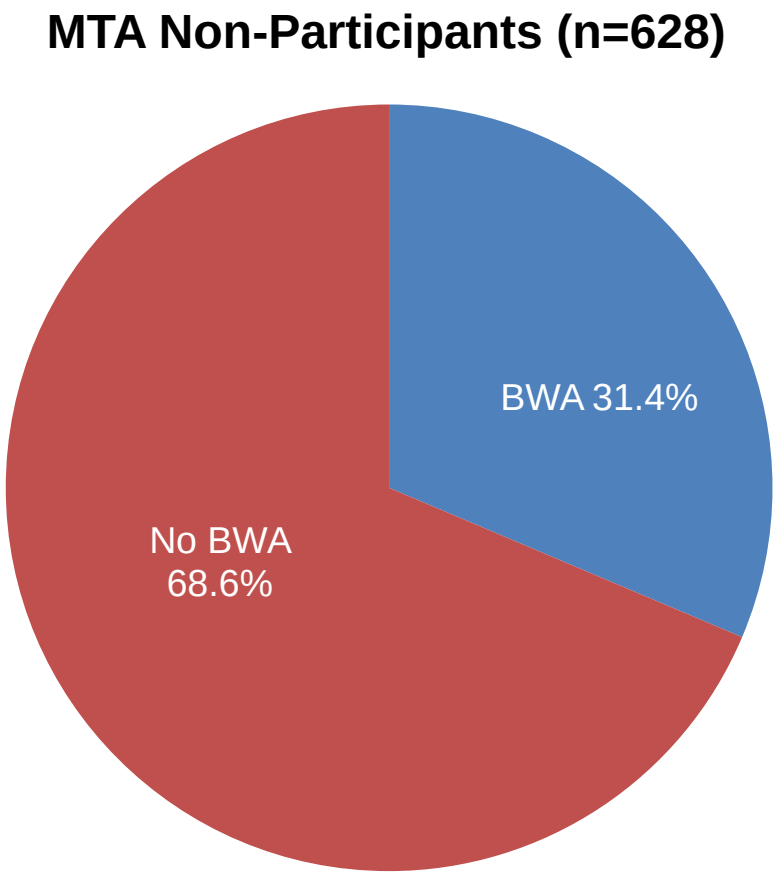
	Distance From Reserve to Closest Population Centre			
	Mean	**Std. Dev.**	**Min**	**Max**
MTA (143)	32.59	65.59	0.2716	416.09
No MTA (610)	64.59	84.80	0.1443	483.49

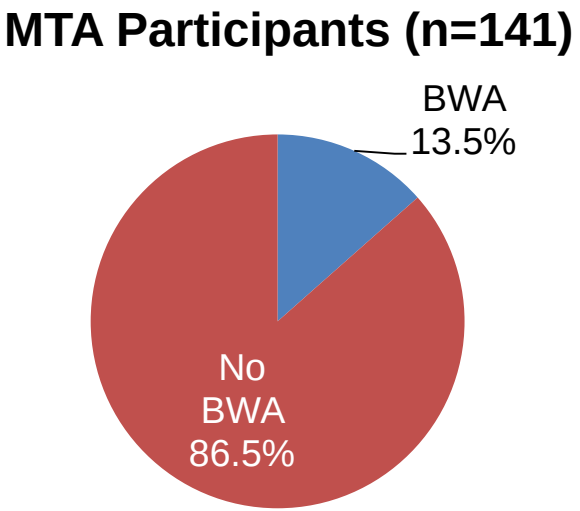
	Reserve Population Density (Persons/km^2)			
	Mean	**Std. Dev.**	**Min**	**Max**
MTA (142)	286.06	494.92	0.2000	3358.9
No MTA (612)	63.252	153.16	0.1000	1453.9

Governance of Drinking Water Safety in First Nation and non-First Nation Communities in Canada



MTAs and Drinking Water Quality





MTA Participation Model:

Population (-)
Population Density (+)

(-)

$$P(MTA = 1|X_M) = \Phi(\alpha_0 + \alpha_1 lnDISTRP + D_r'\beta + TP_c'\gamma + PROV_i'\delta)$$

BWA Model:

(-)

$$P(BWA = 1|X_B) = \Phi(\mu_0 + \mu_1 MTA + ID_s'\pi + WSC'\varphi + \mu_2 lnDISTRP + TP_c'\omega + PROV_i'\vartheta)$$

- Joint Estimation vs. Independent Probit Models

Wald Test Result

$H_0: \rho = 0, H_1: \rho \neq 0$	Estimate	Robust S.E.	95% Confidence Interval	Chi^2	Prob > Chi^2
Base Model	$\hat{\rho}$ = **-0.6368**	**0.3273**	**-0.9500 0.3151**	**1.8700**	**0.1715**

Data

- Water system characteristics
  - Neegan Burnside (2011) → *National Assessment of First Nations Water and Wastewater Systems*
- Reserve Characteristics
  - Demographic Characteristics:
    - 2006 Canadian Census Aboriginal Population Profiles
  - Remoteness
    - 2006 Canadian Census boundary files and GIS software
  - Climate
    - Environment Canada historical climate data

Probit Results – MTA Participation Model

Log pseudolikelihood = -212.712 **Pseudo R^2 = 0.2909** **N = 633**	Marginal Effect (dF/dx)	Robust Std. Error	Z	P>|z|	x-bar	95% Confidence Interval	
Natural Log of Distance Between Reserve and closest population centre (kilometres)	-0.1015	0.0141	-6.71	0.000***	3.2284	-0.1292	-0.0738
Reserve Population (100s)	-0.0095	0.0033	-2.92	0.004***	5.6850	-0.0159	-0.0031
Reserve Area (100s of kilometres)	0.0136	0.0170	0.80	0.425	0.4970	-0.0198	0.0469
Reserve Population Density (100s of persons/km^2)	0.0316	0.0095	3.66	0.000***	1.0293	0.0131	0.0501
10 Year Average Temperature Range (10s of degrees Celsius)	-0.0033	0.0031	-1.09	0.288	40.169	-0.0093	0.0027
10 Year Average Annual Total Precipitation (100s of milliliters)	0.0001	0.0000	1.61	0.108	704.54	-0.0000	0.0001
Reserve Located in Yukon	0.8220	0.0741	4.81	0.000***	0.0111	0.6767	0.9673
Reserve Located in British Columbia	-0.0243	0.0576	-0.41	0.679	0.3776	-0.1371	0.0886
Reserve Located in Alberta	0.4376	0.1070	4.78	0.000***	0.0932	0.2280	0.6472
Reserve Located in Saskatchewan	0.0919	0.0792	1.33	0.184	0.1501	-0.0634	0.2472
Reserve Located in Manitoba	0.2165	0.1119	2.36	0.018**	0.1074	-0.0028	0.4357
Reserve Located in Quebec	0.0714	0.1212	0.68	0.499	0.0284	-0.1661	0.3089
Reserves Located in Atlantic Canada	-0.0371	0.0542	-0.61	0.544	0.0458	-0.1434	0.0691
Obs. P	0.1817						
Pred. P	0.1185	(at x-bar)					

Wald $chi^2(13)$ = 105.20
Prob > chi^2 = 0.0000

Z and P>|z| correspond to the test of the underlying coefficient being 0.
Statistical significance at the 1% (***), 5% (**), and 10% (*) levels.

Probit Estimation Results – BWA Model

Log pseudolikelihood = -307.695 **Pseudo R^2 = 0.1101** **N = 593**	Marginal Effect (dF/dx)	Robust Std. Error	Z	P>|z|	x-bar	95% Confidence Interval	
MTA Participation	-0.1629	0.0465	-2.83	0.005***	0.1551	-0.2541	-0.0718
Independent Water System – Groundwater Source	-0.1112	0.0473	-2.33	0.020**	0.4958	-0.2040	-0.0185
Independent Water System – GUDI Source	0.0200	0.0792	0.26	0.797	0.0641	-0.1351	0.1752
Reserve Population (100s)	-0.0125	0.0060	-2.07	0.039**	5.6134	-0.0243	-0.0007
Reserve Area (100s of kilometres)	0.0174	0.0223	0.78	0.437	0.5080	-0.0263	0.0610
Reserve Population Density (100s of persons/km^2)	0.0080	0.0064	1.24	0.216	0.9539	-0.0046	0.0206
Percentage of Reserve Households Supplied by Piped Water (100s)	0.0008	0.0009	0.91	0.364	89.431	-0.0010	0.0026
Population Serviced by Water System (100s)	-0.0043	0.0048	-0.88	0.377	5.195	-0.0137	0.0052
Age of Water System Servicing Reserve (years)	0.0020	0.0019	1.05	0.294	19.400	-0.0017	0.0057
Natural Log of Distance Between Reserve and closest population centre (kilometres)	0.0278	0.0198	1.40	0.160	3.2626	-0.0110	0.0666
10 Year Average Temperature Range (10s of degrees Celsius)	-0.0047	0.0049	-0.96	0.335	40.441	-0.0142	0.0048
10 Year Average Annual Total Precipitation (100s of milliliters)	-0.0002	0.0001	-1.84	0.066*	699.23	-0.0004	9.9e-06
Reserve Located in Yukon	-0.1903	0.0703	-1.44	0.150	0.0084	-0.3281	0.0525
Reserve Located in British Columbia	-0.2627	0.0730	-3.09	0.002***	0.3643	-0.4057	-0.1196
Reserve Located in Alberta	-0.1006	0.0710	-1.23	0.220	0.0860	-0.2397	0.0385
Obs. P	0.2698						
Pred. P	0.2398	(at x-bar)					

Wald $chi^2(19)$ = 71.36
Prob > chi^2 = 0.0000

Z and P>|z| correspond to the test of the underlying coefficient being 0.
Statistical significance at the 1% (***), 5% (**), and 10% (*) levels.

Probit Estimation Results – BWA Model (Continued)

Log pseudolikelihood = -307.695 **Pseudo R^2 = 0.1101** **N = 593**	Marginal Effect (dF/dx)	Robust Std. Error	Z	P>|z|	x-bar	95% Confidence Interval	
Reserve Located in Saskatchewan	0.0300	0.0751	0.41	0.683	0.1602	-0.1172	0.1772
Reserve Located in Manitoba	-0.1918	0.0458	-2.90	0.004***	0.1062	-0.2815	-0.1021
Reserve Located in Quebec	0.1301	0.1468	0.96	0.336	0.0270	-0.1575	0.4178
Reserves Located in Atlantic Canada	-0.0762	0.0794	-0.86	0.389	0.0489	-0.2317	0.0793
Obs. P	0.2698						
Pred. P	0.2398	(at x-bar)					

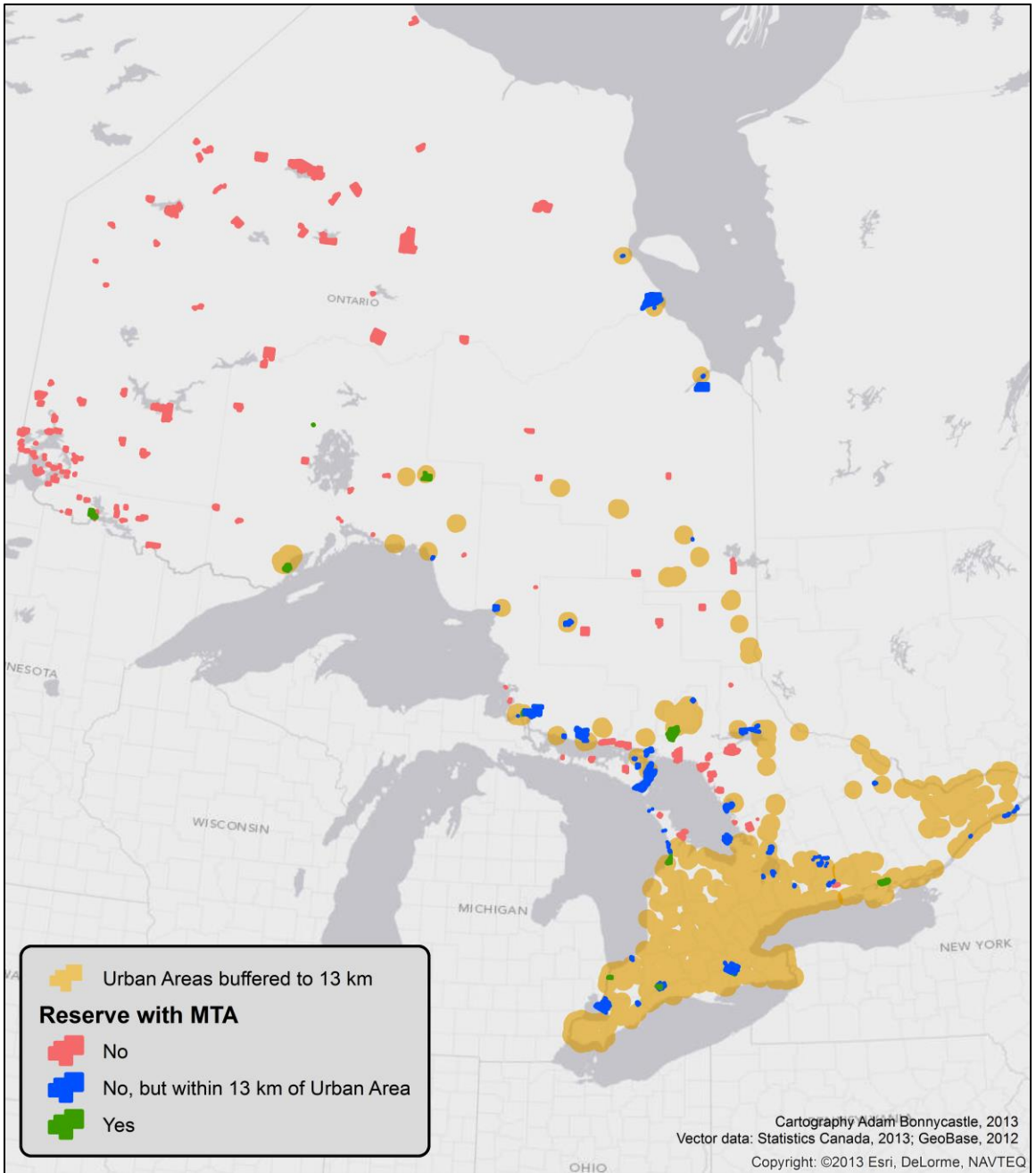
Wald $chi^2(19) = 71.36$
Prob > $chi^2 = 0.0000$

Z and P>|z| correspond to the test of the underlying coefficient being 0.
Statistical significance at the 1% (***), 5% (**), and 10% (*) levels.

Implications

- Of the 654 water systems in the data set without MTAs, 307 fall within a feasible distance to the closest neighbouring POPCT
  - Distance to POPCT is less than the mean distance for MTA participants

Implications



Conclusions

- Participation in a MTA drastically reduces the probability of a BWA being in effect
- Participation decision influenced by demographic characteristics that influence water service provision costs

Recommendations for future research:

- illuminate contract negotiation process, identify areas where transaction costs can be reduced

THANK YOU

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Happy to answer any questions

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