



Qiong Zheng<sup>1</sup>, Michael D. Moran<sup>1</sup>, Junhua Zhang<sup>1</sup>, Emily Tanguay<sup>2</sup>, David Niemi<sup>2</sup>, and Mourad Sassi<sup>3</sup>

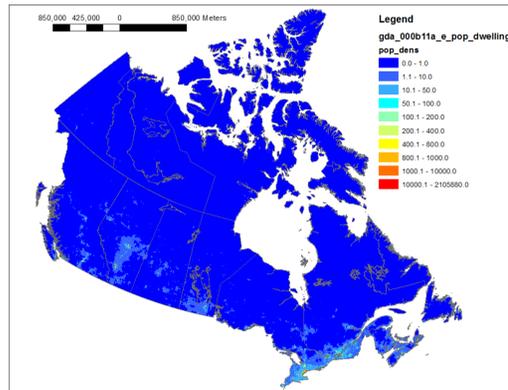
(1) Air Quality Research Division, Environment Canada, Toronto, ON; (2) Pollution Inventory and Reporting Division, Environment Canada, Gatineau, QC; (3) Canadian Meteorological Center, Environment Canada, Montreal, QC

## 1. Introduction

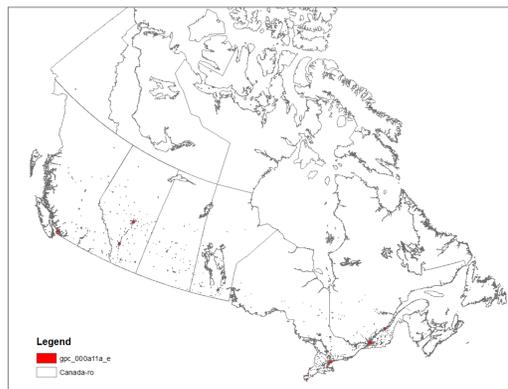
The exact locations of area, on-road, and off-road emissions sources are often unknown. To address this gap, the geographic distributions of these various source types are typically approximated using spatial surrogate fields that are assumed to be representative of the geographic distribution of the emissions. Compared to the U.S., where emissions are reported by county, this approach is especially challenging for Canadian emissions, which are usually reported by province. To respond to this challenge, a number of new Canadian surrogates have recently been developed in several categories.

## 2. Using the 2011 Canadian Census

In the first category, many existing surrogates were built using 2006 Canadian census data, but 2011 census population and dwelling data are now available from Statistics Canada at the dissemination-area (neighbourhood) level. These new census data sets were used to develop new population and dwelling surrogates as well as new on-road mobile surrogates (the latter need the Canadian road network to be separated into urban and rural segments).



2011 population density at Dissemination Area level (unit: number of persons per square kilometre)

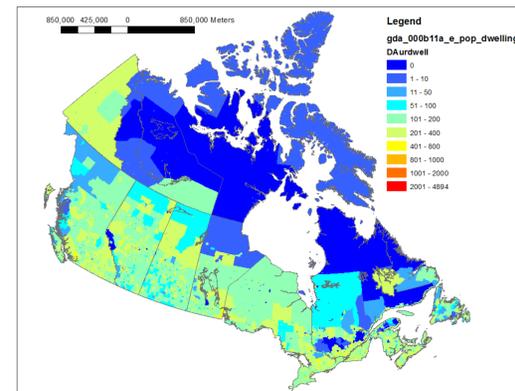


Location of 2011 population-center boundaries (used to separate urban and rural areas)

The original boundary shapefiles were very high resolution (order of meters). They have been simplified to speed up surrogate generation.

### Dissemination area (DA)

These are small areas composed of one or more neighbouring dissemination blocks, and typically with a population of 400 to 700. Canada was divided into 56,204 DAs in the 2011 Census.

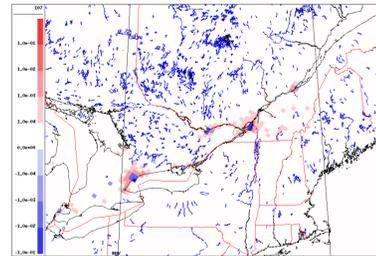


2011 Usual-resident-occupied dwelling counts at Dissemination Area level

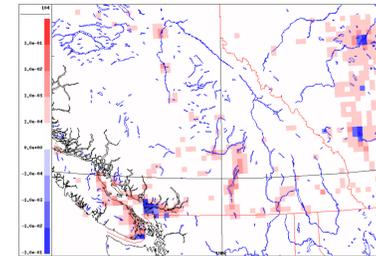
A **population centre** has a population of at least 1,000 and a population density of 400 persons or more per square kilometre. All DAs outside population centres are classified as rural areas.

## 3. Applying Population and Dwelling Density Caps

A second category consists of capped-density surrogates to address the issue that some common surrogates such as population density and dwelling density become less appropriate at smaller grid scales in urban areas, especially in locations where high-rise buildings are concentrated. New capped-density surrogates have been developed to allocate emissions from local traffic, residential meat cooking, and some off-road sources (e.g., lawn mowers, snow blowers).

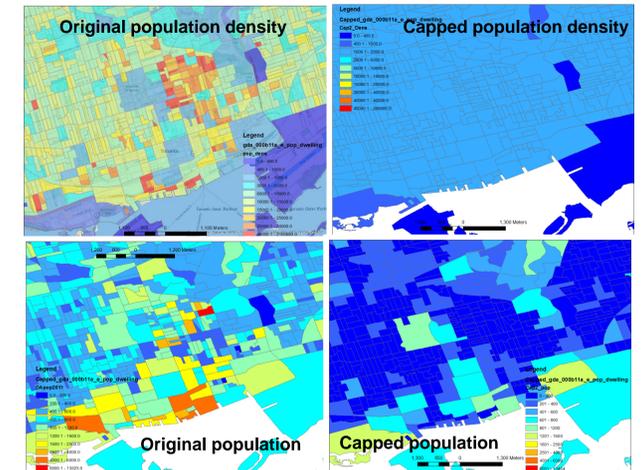


Differences of surrogate 107 for urban local mobile emissions after and before cap applied over southern Ontario and Quebec on GEM-MACH15 model grid.



Differences of surrogate 104 (Capped Occupied total dwelling) and surrogate 101 (Occupied total dwelling) over southern BC and Alberta on GEM-MACH15 grid.

Based on Gately et al. (2013, *ES&T*, 47, 2423–2430), caps (i.e., upper bounds) of 2,000 persons/km<sup>2</sup> for population density and 600 dwellings/km<sup>2</sup> for dwelling density were applied.



Comparison of 2011 population density and total population over downtown Toronto before and after cap was applied.

## 4. Building a New Spatial Surrogate for Residential Wood Combustion

Residential wood combustion (RWC) is one of the biggest PM emission sources for Canada, especially during the winter, and improving the spatial allocation of these emissions can have a substantial impact on model skill. A new wood consumption surrogate for RWC was built using recent wood consumption data from Statistics Canada plus information about differences in urban/rural behaviour, dwelling density (capped), proximity to forests, and latitude.

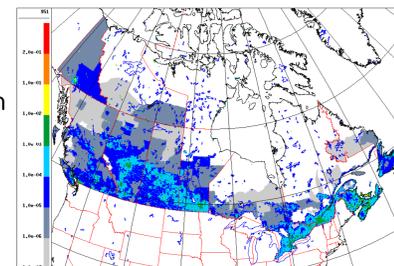
### 2010 annual RWC emissions for Canada (in tons/year)

Species	RWC	Canada total	Percentage
PM2.5	114,735	625,875	18%
PM10	114,875	2,750,985	4%

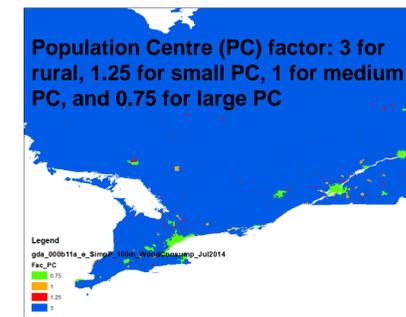
Provincial fuelwood consumption information based on Statistics Canada Households and the Environment Survey (HES) and its Energy Use Supplement

Province	Provincial Wood Consumption	CMA Wood Consumption	Provincial Percent Urban	CMA Rural Consumption
Newfoundland	339,600	35,202	0.11	31,330
PEI*	56,600	0	0.23	0
Nova Scotia	403,275	57,642	0.14	49,572
New Brunswick	374,975	29,373	0.08	27,023
Quebec	3,459,675	903,116	0.26	633,729
Ontario	1,648,475	424,555	0.27	295,096
Manitoba	162,725	18,006	0.12	15,845
Saskatchewan	127,350	15,035	0.12	13,231
Alberta	233,475	54,745	0.25	41,059
British Columbia	749,950	153,648	0.21	121,382
Yukon*	8,199	0	0.23	0
Northwest*	17,859	0	0.23	0

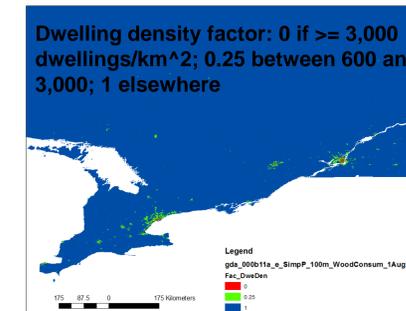
New RWC Surrogate 951 (Wood Consumption Percentage) on GEM-MACH15 model grid



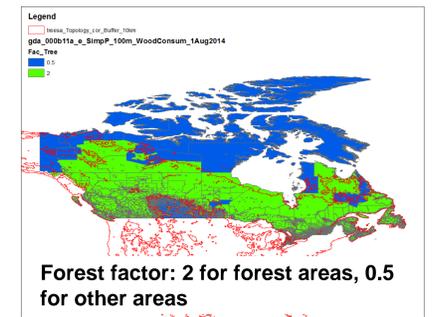
**Assumption 1:** Rural households (as represented by dwellings) will burn more wood on average than urban households; rural households are much more likely to use RWC for space heating than urban households.



**Assumption 2:** Wood burning is unlikely to occur in high-density, multi-storey, multiple-unit buildings.



**Assumption 3:** Households located within or close to forests are more likely to burn wood than households located in prairie or cleared (agricultural) locations (e.g., southwestern Ontario).



**Assumption 4:** RWC for space heating will be higher in colder locations.

