Wildfire CAC Emission Inventory for 2011

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Victoria, BC

2012

Background

Historical methods of estimating Common Air Contaminants (CAC) emissions from wildfires usually involves the use of a single emission factor for each CAC and the area burned or the mass of vegetation burned. While this method is numerically expedient, it leads to large uncertainties due to the widely varying types of forest cover throughout the province. Forest types in British Columbia can range from coastal temperate rainforest to dry interior ponderosa to sub-arctic scrub. This report covers the CACs Particulate Matter in 3 size ranges; Total, less than 10 micron and less than 2.5 micron (PM-T, PM 10, PM 2.5), Carbon Monoxide (CO), Oxides of Nitrogen (NOx), Oxides of Sulphur (SOx) and Non-Methane Hydrocarbons (NMHC).

A first step in improving the estimation of emissions from wildfires would be the use of a model that could take into account the different types of forest cover in the calculation of emissions while not requiring a high level of data to describe the scenario. Many forestry agencies and academics have models to estimate fire growth and emissions however they generally require a high level of input data such as actual vegetation loadings on the ground and in each layer of the canopy, data that would be available in a pilot project or research scale investigation but not on a routine basis across the province.

However, there is a relatively simple model that incorporates a high level of built in data about the forest structure and fire behaviour. The model used is CONSUME (version 3.0) in conjunction with the Fuel Characteristic Classification System and run in the wildfire mode.

Method

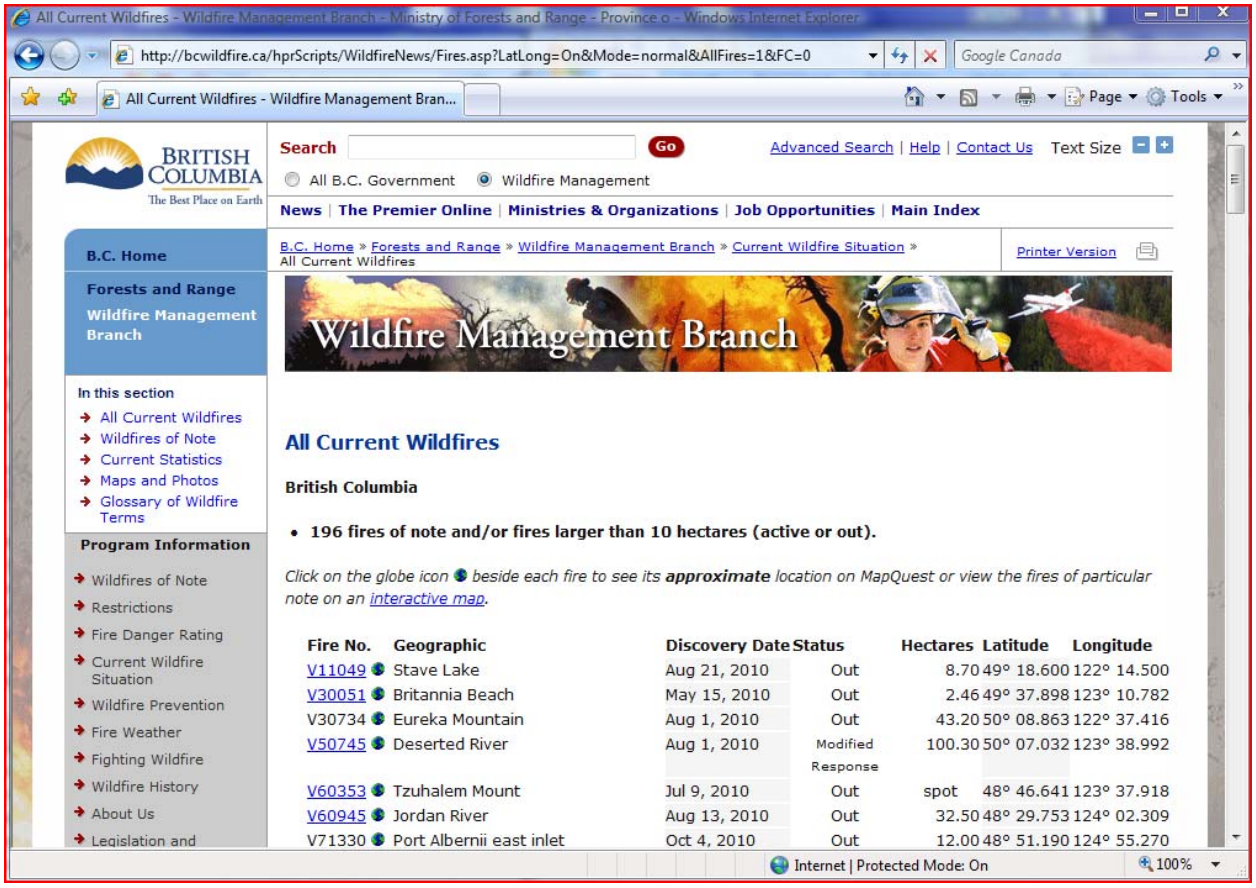
The procedure was developed in two parts: collection of the wildfire data and use of the CONSUME model to produce emission estimates.

Collection of Wildfire Data

Wildfire Management Headquarters of the Ministry of Forests, Lands and Natural Resource Operations compiles information about wildfires in the province as well as other information such as Fire Danger rating and Burning Restrictions. This information is presented on the webpage (http://bcwildfire.ca) under the subheading of “Current Wildfire Situation”. On the sub-page the viewer may select summary statistics for the year to date or a list of all Wildfires of Note. These are fires generally larger than 10 ha and those of interest to the public due to location and intensity.

The information presented on the Wildfires of Note list includes the fire name, start date, size and location (latitude and longitude). An example of this page is shown below in Figure 1:

Figure 1: Example of Wildfire Webpage



The data from this list was transferred into an EXCEL spreadsheet to facilitate calculations and the addition of further data. The location data of each fire was used to lookup the Biogeoclimatic Zone in Hectares BC which provides a description of the forest cover at that point. HectaresBC is a tool to display geospatial data analysis of natural resource information (http://www.hectaresbc.org). The Biogeoclimatic Zone data selected for this project gives a description of the type of the forest cover.

CONSUME model

The fire and emission model used is the CONSUME model version 3.0 (written by Prichard, S., Ottmar, R., (and Anderson, G.) of the Fire and Environmental Research Applications (FERA) Team, Pacific Wildland Fire Sciences Lab, USDA Forest Service, Seattle).

While the main objective of the CONSUME model is to provide land managers with a tool to meet management objectives such as logging slash reduction, ecosystem and wildlife restoration, etc., it also

has an excellent wildfire module that requires minimum data to execute.

The CONSUME model works in conjunction with the Fuel Characteristic Classification System (FCCS), version 2.0 (written by Prichard, S., Sandberg, D., Ottmar, R., Campbell, P.). The flexible design of FCCS allows users to represent the structural complexity and diversity of fuels created through natural processes and management activities. Each fuelbed is organized into six strata, including canopy, shrubs, nonwoody fuels (i.e., grasses and other herbaceous vegetation), woody fuels, litter-lichen-moss, and ground fuels. Strata are further divided into categories and subcategories. Over 200 FCCS fuelbeds, representing common fuel types throughout much of North America, are available in the FCCS reference library. Users may select a FCCS fuelbed to represent their specific project or customize a fuelbed to reflect actual site conditions.

When CONSUME is run in the wildfire mode, the user need only identify the FCCS fuelbed that best represents the forest cover description provided by HectaresBC and supply the area burned in order to estimate emissions.

CONSUME does not estimate sulphur oxides nor nitrogen oxides emissions. Sulphur oxide emissions do vary somewhat with the soil characteristics. Nitrogen oxide emissions are more a function of the process rather than the fuel, with emissions being a function of the combustion temperature. Emission estimations for sulphur oxides and nitrogen oxides will use the previous emissions factor developed by Environment Canada in 2006, as shown in Table 1:

Table 1: Emission Factors for SOx and NOx

Emission Factors (kg/ha)	
SOx	NOx
0.865	34.6
Taken from Env. Can. Emissions and Projections Working Group 2006 Emissions Inventory Guidebook	

Results

Provincial Summary

After a record year in 2010, the wildfire year of 2011 turned out to be a record of another sort. Only 647 wildfires were recorded for 2011. The previous lowest record in the last 10 years was 976 in 2005. The total area burned was 12,423 ha. Although this is not a recent record (the lowest area burned in the last 10 years was 8,539 ha in 2002), almost all of the 2011 area burned was from one fire in the Northwest zone that was allowed to burn out naturally. This fire (R90015, Blue River) was recorded at 11,000 ha. Without this fire, the total area burned would only be 1,423 ha.

The Wildfires of Note list contained only 26 fires (4.0% of the total number) with a total area burned of 12,053 ha (97.0% of the total area). This seemingly lopsided result stems from the Forest Service policy to attack fires fast and hard especially in areas with valuable timber or human habitation, thus a high majority of the fires tend to be small spot fires that are extinguished within 12 to 24 hours.

Table 2 presents the CAC emissions from the 2011 wildfires for the province:

Table 2: 2011 Provincial Wildfire CAC Emission Estimates (tonnes)

PM-T	PM 10	PM 2.5	CO	NOx	SOx	NMHC
9,156	6,125	5,660	55,210	417	10	2,622

Regional Summary

In this report Regional Summaries are based on former Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) regions as shown in Figure 2:

Figure 2: Map of MFLNRO Regions

Table 3 presents a breakdown of the number of fires (Total and Wildfires of Note (WoN)) and the area burned (ha) by MFLNRO regions:

Table 3: Regional Breakdown of Fires and Area Burned (ha)

	Coastal	Northwest	Pr. George	Kamloops	Southeast	Cariboo
Total No.	90	20	105	243	132	56
WoN No.	2	1	9	8	2	4
Total Area	27	11,012	474	589	62	179
WoN Area	11	11,000	398	461	28	155

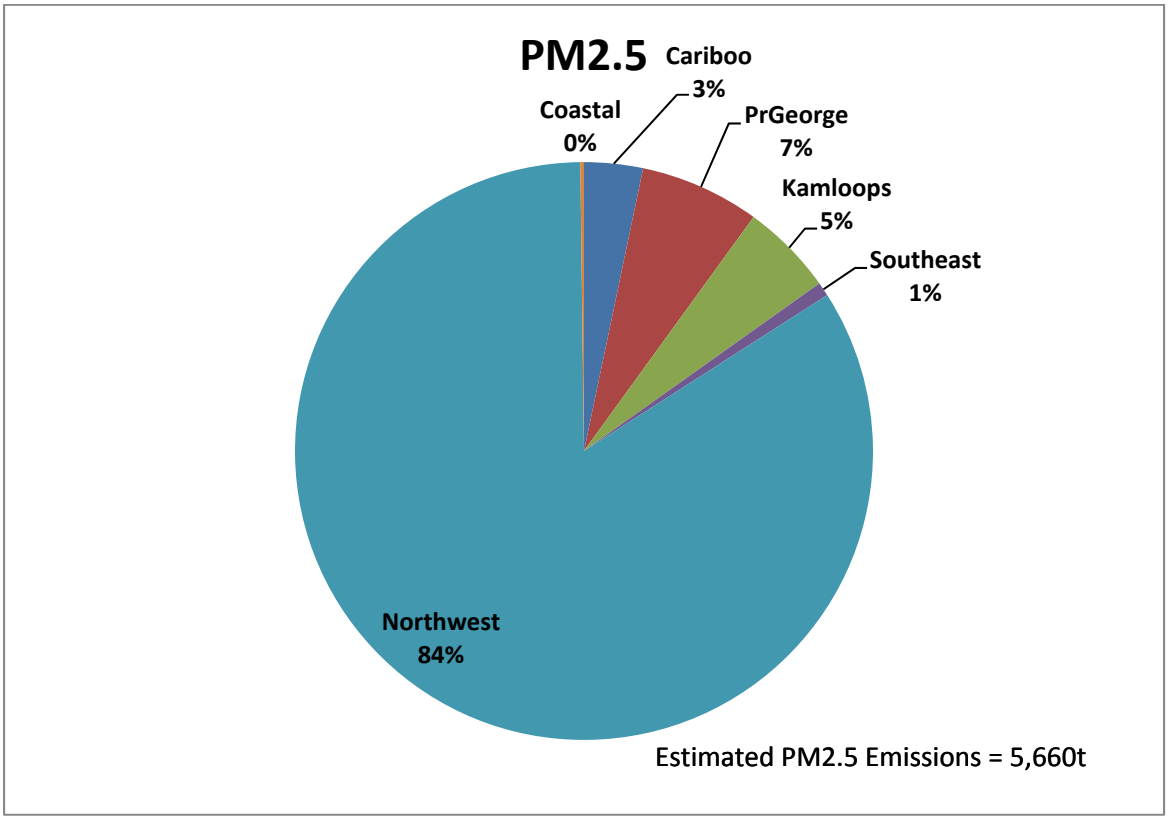
Table 4 presents the estimated emissions (tonnes) of all CACs by MoF region:

Table 4: Regional Breakdown of Estimated Emissions (tonnes)

	PM-T	PM10	PM2.5	CO	NOx	SOx	NMHC
Cariboo	268	198	186	2,498	5	0	76
PrGeorge	576	406	293	3,595	14	0	162
Kamloops	488	314	293	3,218	16	0	77
SouthEast	65	47	44	498	1	0	22
NorthWest	7,741	5,147	4,747	45,280	381	10	2,279
Coastal	18	13	12	121	0	0	6

Using PM 2.5 as an example, Figure 3 presents the average distribution of emissions by regions

Figure 3: 2011 PM 2.5 Emissions by Region

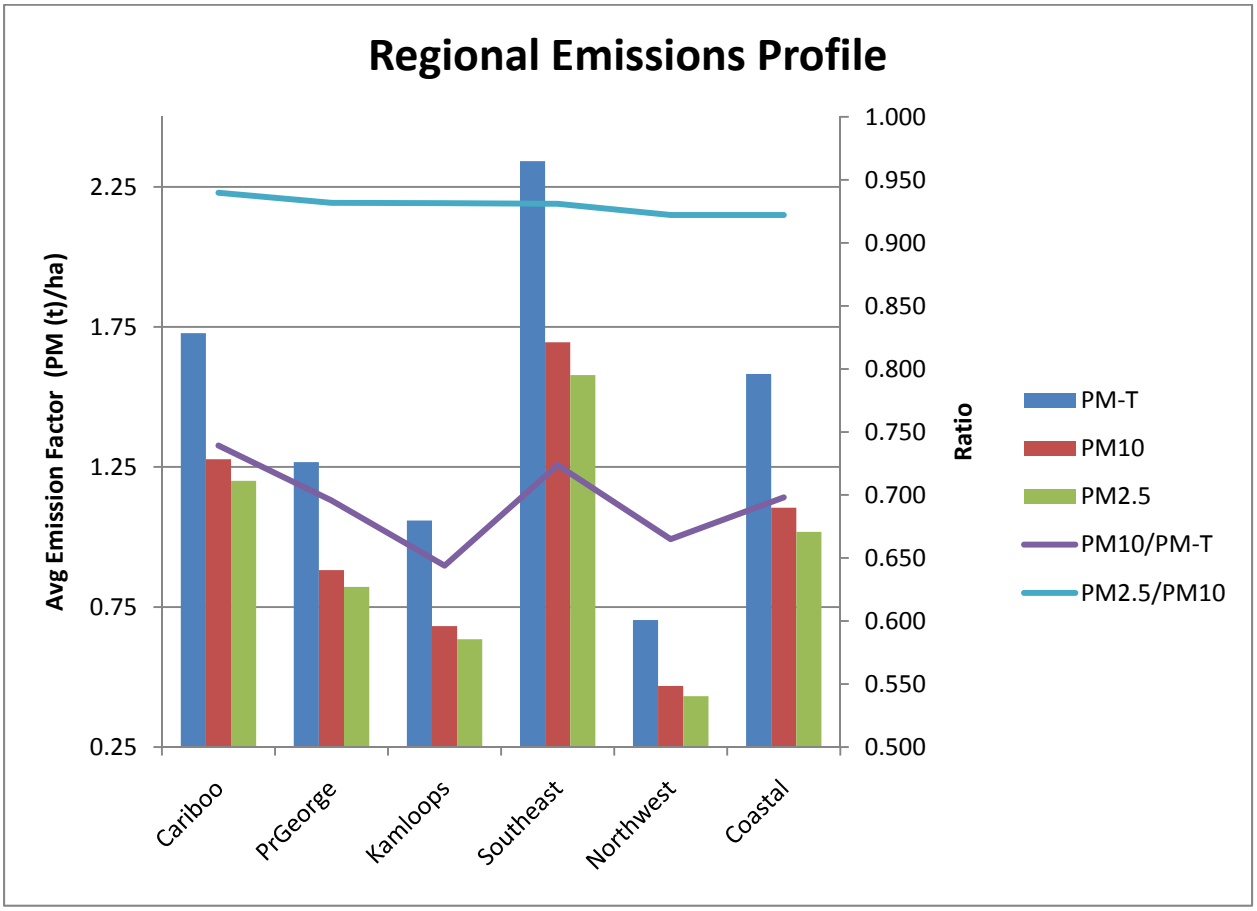


A high majority of the provincial emissions resulted from the one fire in the Northwest region. This fire occurred in non-productive forest lands and was allowed to burn out naturally.

Discussion

One of the objectives of using a model like CONSUME instead of traditional emission factors, was to capture how the differing forest cover and combustion processes affect the contaminant emissions in forest types throughout the province. Figure 4 presents the average emissions per hectare (Emission Factor, EF), shown by the vertical bars, as well as the average emission ratio of PM 10 to PM-T and PM 2.5 to PM 10 shown by the horizontal lines, sorted by MFLNRO region.

Figure 4: 2011 Regional PM EFs and PM Ratios



While MFLNRO regions are not strictly aligned with biogeoclimatic regions, the results show that the average emission factor differs by region. The low number of fires per region shows some interesting results with a larger range of emission factors from region to region.

The emission ratios of PM 10 to PM-T and PM 2.5 to PM 10 also show a differing profile over the regions, with wider range of ratios. This further indicates that the model is accounting for the differing forest types in the emission calculations.

Comparison to Anthropogenic Emissions

Table 5 shows the emission estimates for the Common Air Contaminants from the 2005 inventory for anthropogenic sources (not including road dust) and the wildfire emissions reported here.

Table 5: 2011 Provincial Emission Estimates

CAC	2005 Anthropogenic Emissions	2011 Wildfire Emissions
CO	1,478,408	55,210
NOx	235,291	417
SOx	110,348	10
VOC (2005)/NMHC (2011)	202,067	2,622
PM-T	184,166	9,156
PM 10	111,375	6,125
PM 2.5	71,336	5,660

2011 wildfire emissions of the common air contaminants were extremely low compared to anthropogenic emissions due to the low number of fires.

Conclusions

Common Air Contaminant emissions were estimated using a fire growth and emissions model (CONSUME version 3.0) and the Wildfire Management Branch Wildfires of Note database. The MFLNRO Wildfires of Note database contained 26 fires (4.0% of the total number of fires) but represented 97.0% of the total area burned in the province in 2010.

The number of fires in 2011 was the lowest over the last 10 years of record while the area burned was the 3rd lowest, although one fire in the north of the province accounted for 89% of the provincial total.

Analysis of the results showed that the average emission factor differed by region indicating that the CONSUME model was accounting for the different forest types within the biogeographic zones in the province.