Wildfire CAC Emission Inventory for 2010

Warren McCormick

Ministry of Environment

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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

The former Wildfire Management Branch 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

While the number of fires in 2010 was slightly below the latest 10 year average, 1,670 compared to 1,784, the area burned was the highest by far in the last 10 years. The average area burned has been about 75,000 ha with the previous maximum of 265,000 ha in 2003. The total area burned in 2010 was 331,090 ha, with a majority of this in the Cariboo region.

The Wildfires of Note list contained 196 fires (11.7% of the total number) with a total area burned of 330,204 ha (99.7% of the total area). This seemingly lopsided result stems from the Forest Service policy

to hit 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 2010 wildfires for the province:

Table 2: Provincial CAC Emission Estimates (tonnes)

PM-T	PM 10	PM 2.5	CO	NOx	SOx	NMHC
680,825	496,753	465,486	4,537,749	11,425	286	156,124

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.	204	167	474	267	227	331
WoN No.	9	24	53	24	12	74
Total Area	4,804	126,032	26,843	3,971	1,307	168,133
WoN Area	4,762	125,932	26,483	3,863	1,221	167,943

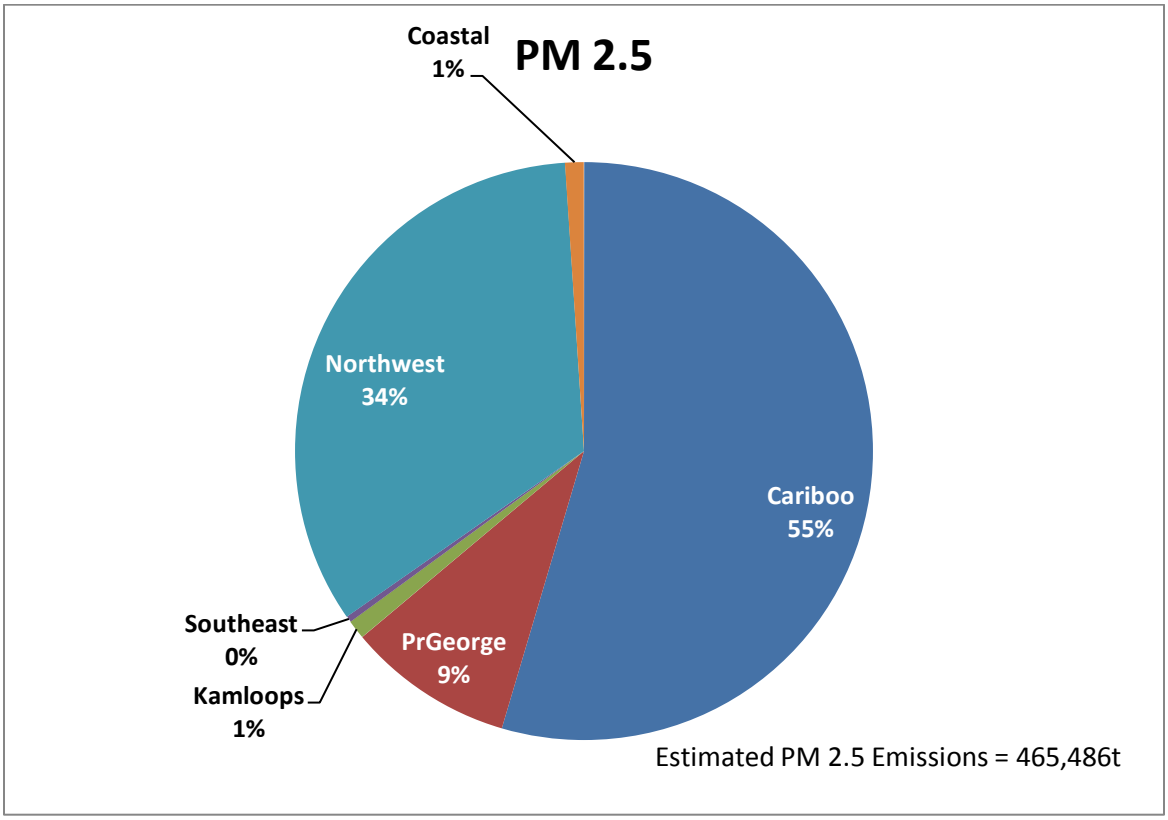
Table 4 presents the estimated emissions (tonnes) of all CACs by MoF region:

Table 4: Regional Breakdown of Estimated Emissions (tonnes)

	PM-T	PM10	PM2.5	CO	NOx	SOx	NMHC
Cariboo	366,570	270,519	254,075	2,596,789	5,811	145	77,979
PrGeorge	63,488	46,287	43,332	369,672	916	23	13,459
Kamloops	7,136	5,254	4,936	65,238	134	3	1,970
SouthEast	2,323	1,742	1,645	24,058	42	1	595
NorthWest	233,770	167,684	156,640	1,431,093	4,357	109	59,630
Coastal	7,538	5,267	4,858	50,898	165	4	2,491

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

Figure 3: PM 2.5 Emissions by Region

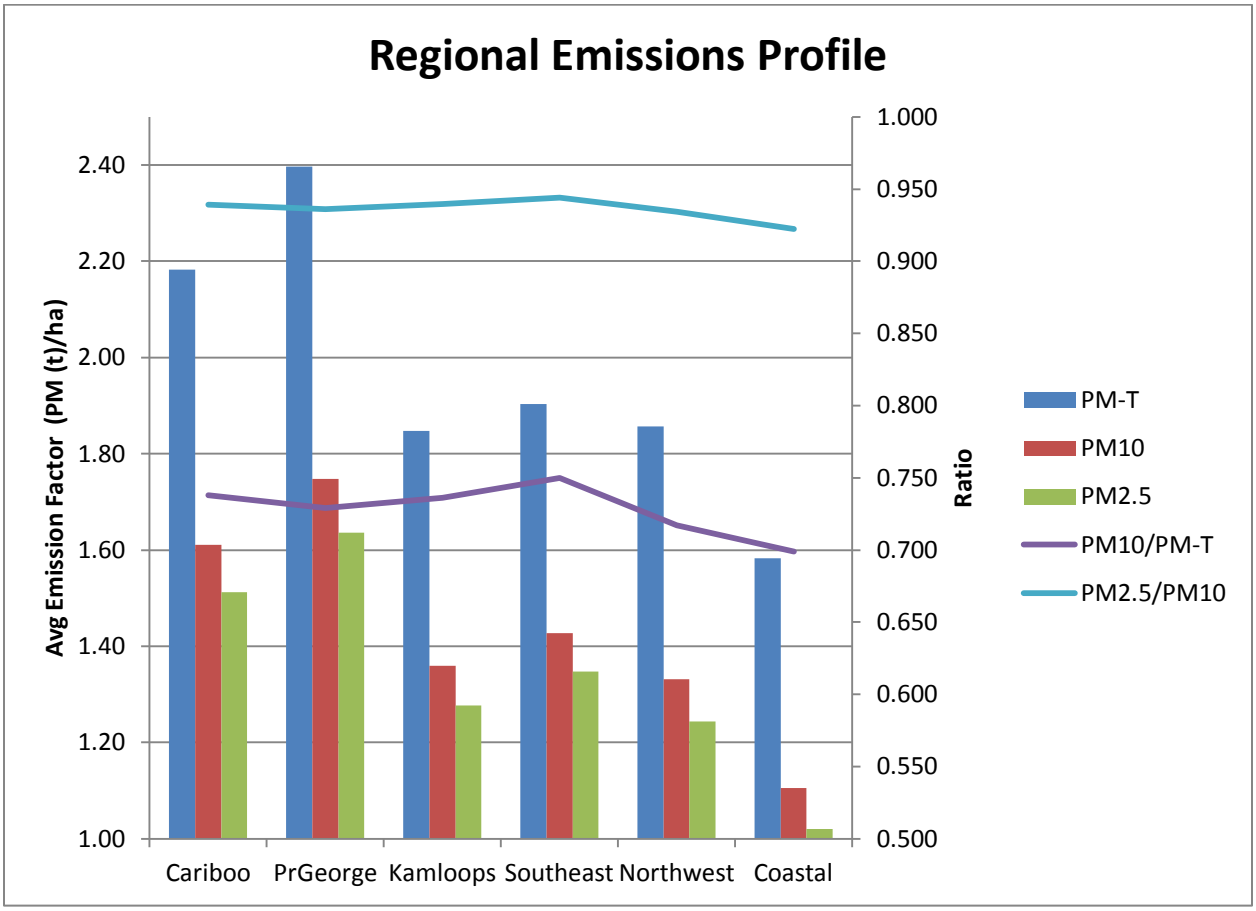


The Cariboo region was hardest hit in 2010 with many large fires occurring in the pine beetle ravished areas west of Williams Lake and Quesnel. Fires in the North West regions were second in emissions however, some larger fires in this region (as well as some in the Prince George region), occurred in unproductive forest and remote from any settlements and the Forest Service allows these fires to burn in a managed response.

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: 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. For PM-T the emission factors range from a high of 2.40 in the PrGeorge region to a low of 1.55 in the Coastal region. Emission factors for PM 10 and PM 2.5 also follow the same profile. This is an encouraging result as it shows that the differing forest type in these regions has an effect on the calculated contaminant emission rates.

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 a peak in the ratios in the Southeast region to a low in the Coastal region. 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: Provincial Emission Estimates

CAC	2005 Anthropogenic Emissions	2010 Wildfire Emissions
CO	1,478,408	4,537,749
NOx	235,291	11,425
SOx	110,348	286
VOC (2005)/NMHC (2010)	202,067	156,124
PM-T	184,166	680,825
PM 10	111,375	496,753
PM 2.5	71,336	465,486

Wildfire emissions overwhelm anthropogenic emissions for CO and the PM species by a factor of 3 and 6, respectively. CO and PM emissions from combustion sources are related to the degree of control in the combustion process. Open burning is considered uncontrolled combustion thus it is expected that the emissions of these parameters would be significant.

However, wildfire emissions of SOx and NOx are a small fraction of anthropogenic emissions. This result also reflects the combustion process. NOx formation is related to the combustion temperature. Open burning has a relatively low combustion temperature compared to controlled combustion in anthropogenic sources such as boilers, furnaces and internal combustion engines. Sulphur oxide emissions are related directly to sulphur in the fuel. Wood has very little sulphur compared to fossil fuels used in anthropogenic sources.

Conclusions

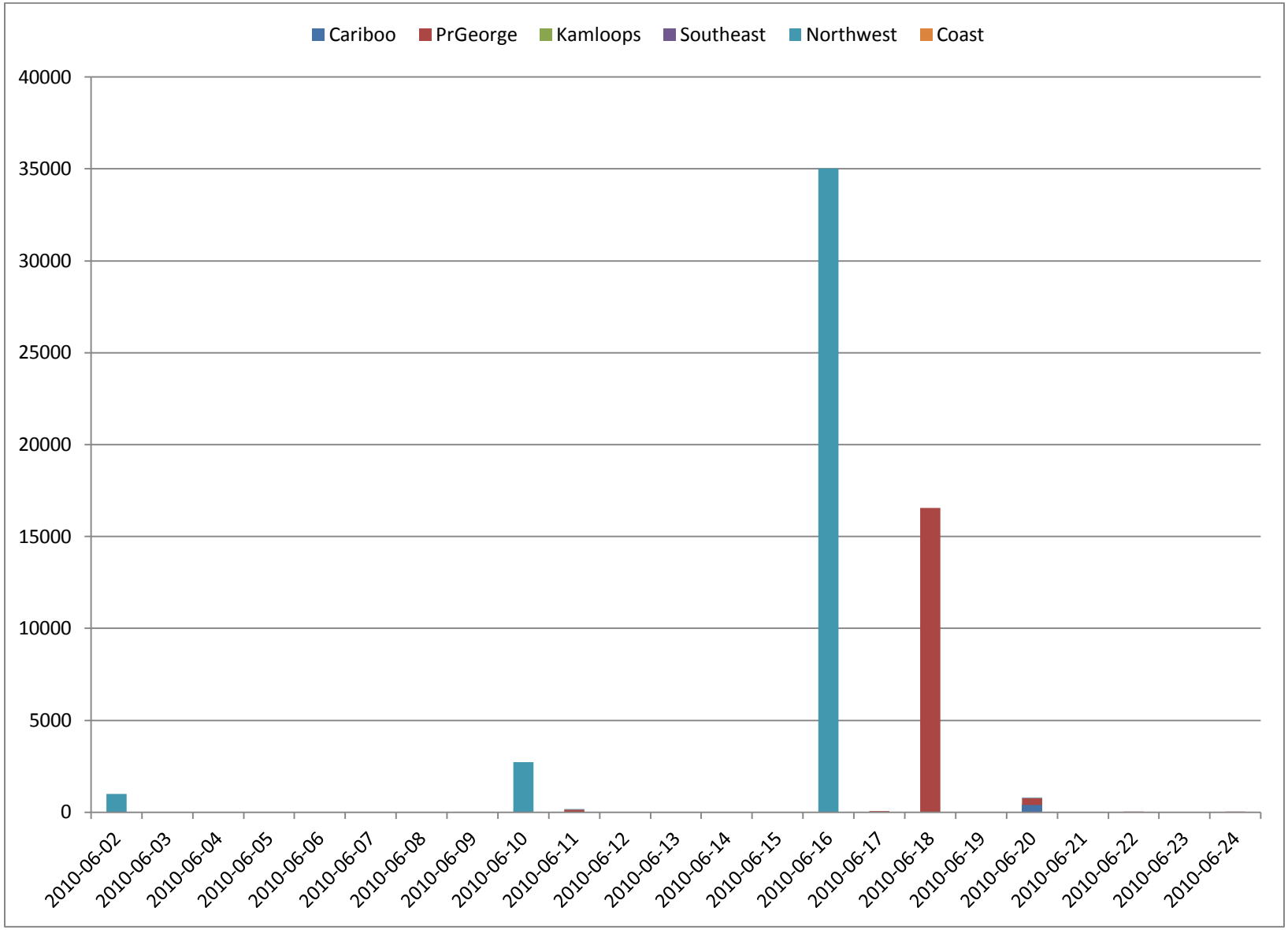
Common Air Contaminant emissions were estimated using a fire growth and emissions model (CONSUME version 3.0) and the Wildfire Management Branch Wildfires of Note database. The MFLNRO Wildfires of Note database contained 196 fires (11.7% of the total number of fires) but represented 99.7% of the total area burned in the province in 2010.

The area burned in 2010 was the highest over the last 10 years of record and was over 4 times the 10 year average. Over 50% of the area burned occurred in the Cariboo region, most of those fires were just west of Williams Lake and Quesnel.

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.

Appendix 1: Time Line of Emissions

The following graphs show the particulate (PM-T) emissions by date of ignition and region.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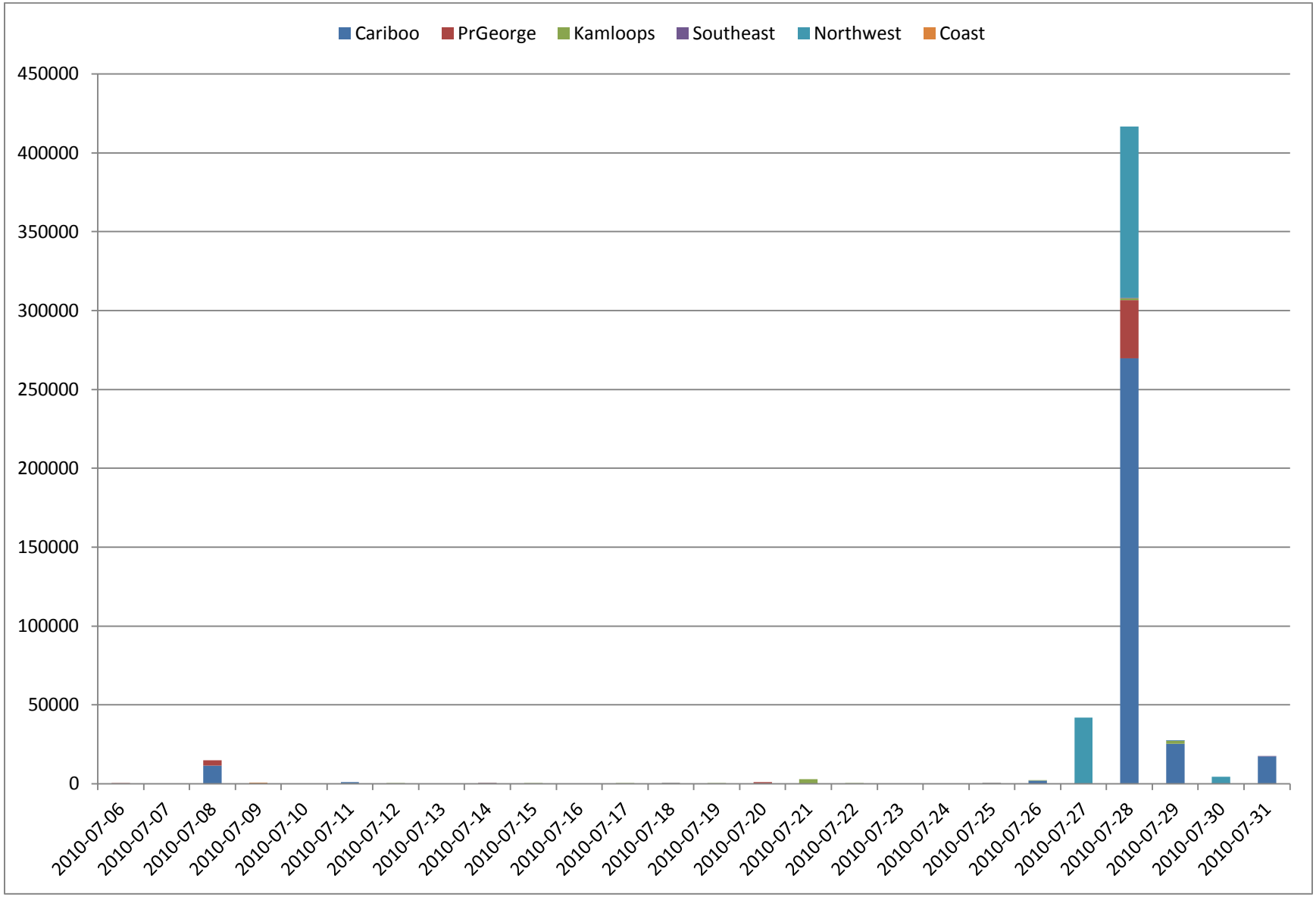
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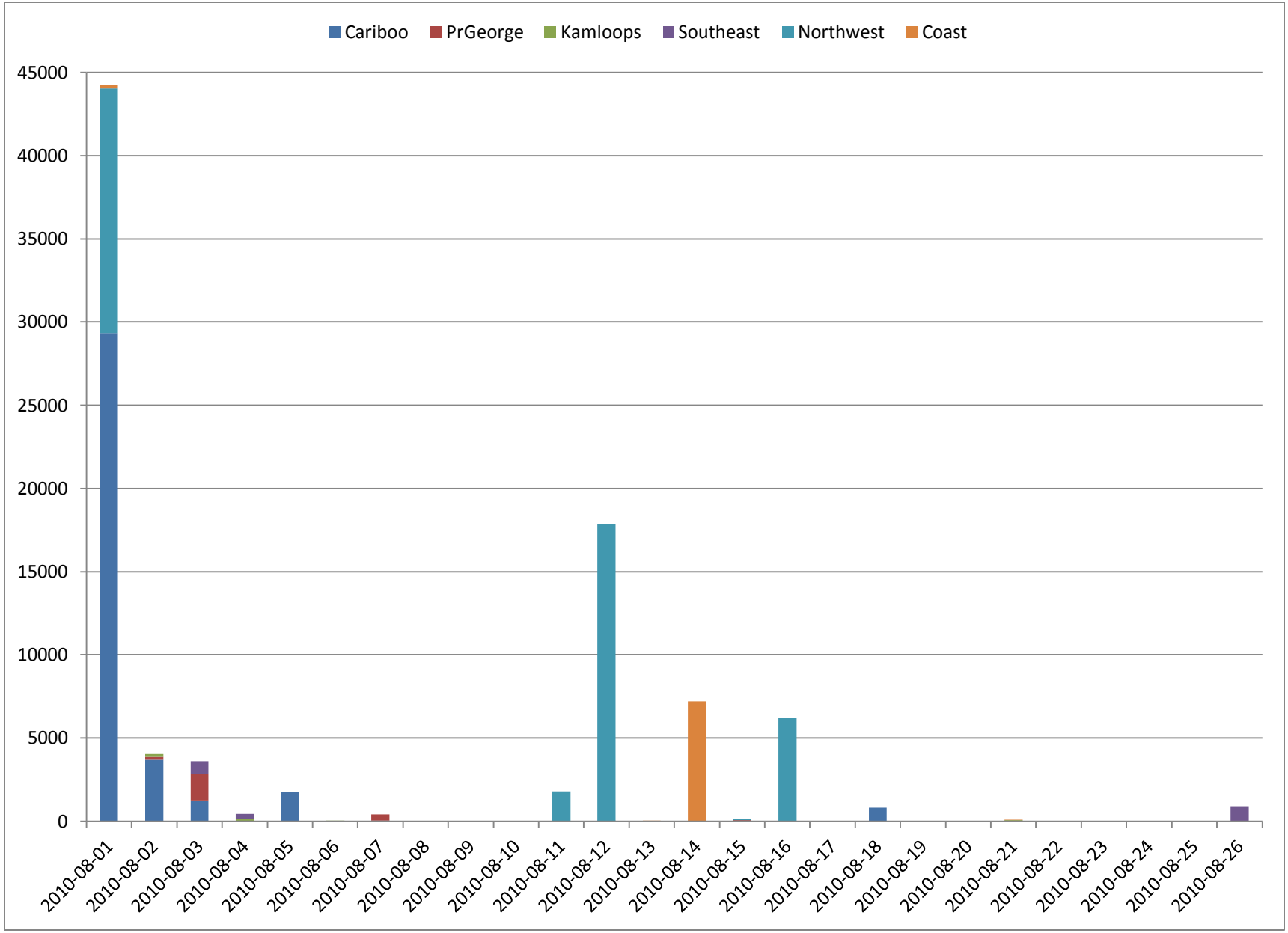
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