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ABOVE: Wildfire Carbon Emissions and Burned Plot Characteristics, NWT, CA, 2014-2016

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Data Set Version: 1

Summary

This dataset provides estimates of wildfire carbon emissions and uncertainties at 30-m resolution, and measurements collected at burned and unburned field plots from the 2014 wildfire sites near Yellowknife, Northwest Territories (NWT), Canada. Field data were collected at 211 burned plots in 2015 and include site characteristics, tree cover and species, basal area, delta normalized burn ratio (dNBR), plot characteristics, soil carbon, and carbon combusted. Data were collected at 36 unburned plots with characteristics similar to the burned plots in 2016. The emission estimates were derived from a statistical modeling approach based on measurements of carbon consumption at the 211 burned field plots located in seven independent burn scars. Estimates include uncertainty of field observations of aboveground and belowground combustion, as well as prediction uncertainty from a multiplicative regression model. To apply the model across all 2014 NWT fire perimeters, the final model covariates were re-gridded to a common 30-m grid defined by the Arctic Boreal and Vulnerability Experiment (ABOVE) Project. The regression model was then applied to burned pixels defined by a threshold of Landsat-derived differenced Normalized Burn Ratio (dNBR) within fire perimeters. Derived carbon emissions and uncertainty in g/m² are provided for each 30-m grid cell. The modeled NWT domain encompasses 29 tiles within the ABOVE 30-m reference grid system.

There are 60 data files in GeoTIFF (.tif) format and one data file in comma-separated (.csv) format with this dataset. The GeoTIFF files provide carbon consumption and consumption uncertainties separately for each of the 29 ABOVE reference grid tiles for the NWT domain. There is also a consumption data file and an uncertainty data file covering the entire domain. The .csv file provides plot characteristics, soil carbon, and estimated carbon combustion data.

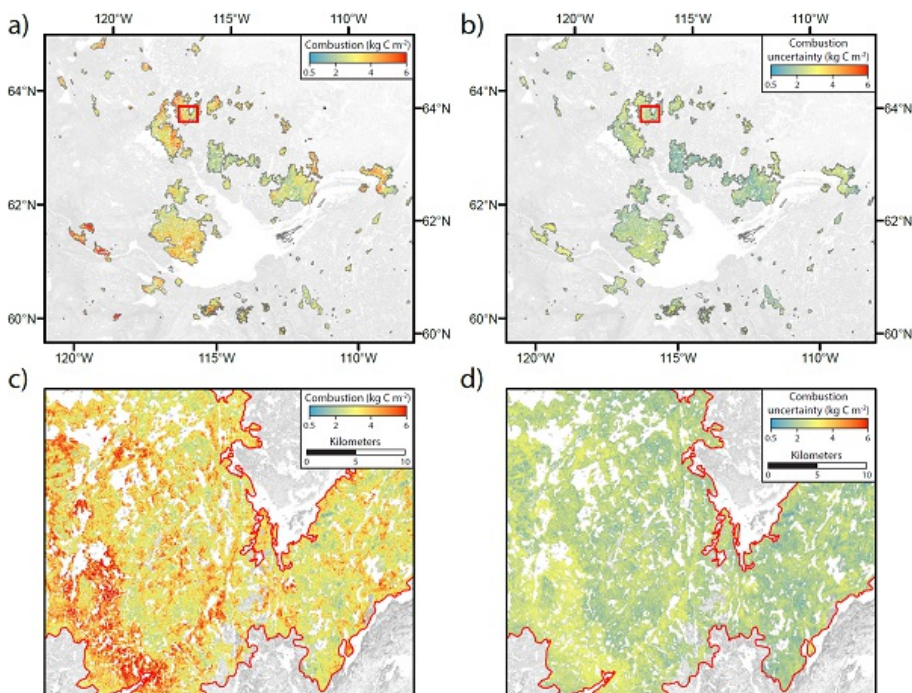


Figure 1. Maps of the 2014 NWT fire complex showing a) estimated total combustion, b) uncertainty in total combustion, and details of landscape heterogeneity in c) combustion and d) uncertainty within one of the major fire scars. From Walker et al., 2018.

Citation

Walker, X.J., B.M. Rogers, J.L. Baltzer, S.R. Cummings, N.J. Day, S.J. Goetz, J.F. Johnstone, M.R. Turetsky, and M.C. Mack. 2018. ABOVE: Wildfire

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1. Data Set Overview

The focus of this study was to develop a high spatial resolution model to scale emissions from fires that occurred near Yellowknife, Northwest Territories, Canada, during 2014. A model was derived using only covariates obtainable from geospatial layers that covered the entire spatial domain of interest. The final model was used to estimate total C emissions at 30-m resolution across all fires in the 2014 NWT fire complex.

To apply the model across all fire perimeters, final model covariates were re-gridded to a common 30-m grid and Canadian Albers Equal Area Conic projection defined by 29 tiles within the ABoVE 30-m reference grid (Loboda et al., 2017). The regression model was then applied to burned pixels defined by a threshold of Landsat-derived differenced Normalized Burn Ratio (dNBR) within fire perimeters.

A Monte Carlo framework was adopted to quantify predictive uncertainty assumed to arise from measurement error in aboveground and belowground combustion, and landscape scaling.

Plot data collected at the wildfire burned sites and from unburned sites with similar characteristics are also included with this dataset. The plot data include site characteristics, tree cover and species, basal area, dNBR, plot characteristics, soil carbon, and carbon combusted. Combustion related data were not collected at unburned plots.

Project: Arctic-Boreal Vulnerability Experiment

The Arctic-Boreal Vulnerability Experiment (ABoVE) is a NASA Terrestrial Ecology Program field campaign based in Alaska and western Canada between 2016 and 2021. Research for ABoVE links field-based, process-level studies with geospatial data products derived from airborne and satellite sensors, providing a foundation for improving the analysis and modeling capabilities needed to understand and predict ecosystem responses and societal implications.

Related Datasets:

Bourgeau-Chavez, L.L., S. Endres, L. Jenkins, M. Battaglia, E. Serocki, and M. Billmire. 2017. ABoVE: Burn Severity, Fire Progression, and Field Data, NWT, Canada, 2015-2016. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1548>

Bourgeau-Chavez, L.L., N.H.F. French, S. Endres, L. Jenkins, M. Battaglia, E. Serocki, and M. Billmire. 2016. ABoVE: Burn Severity, Fire Progression, Landcover and Field Data, NWT, Canada, 2014. ORNL DAAC, Oak Ridge, Tennessee, USA. <http://dx.doi.org/10.3334/ORNLDAAC/1307>

Loboda, T.V., E.E. Hoy, and M.L. Carroll. 2017. ABoVE: Study Domain and Standard Reference Grids. ORNL DAAC, Oak Ridge, Tennessee, USA. <http://dx.doi.org/10.3334/ORNLDAAC/1367>

Veraverbeke, S., Rogers, B. M., Goulden, M. L., Jandt, R., Miller, C. E., Wiggins, E. B., & Randerson, J. T. (2017). ABoVE: Ignitions, burned area and emissions of fires in AK, YT, and NWT, 2001-2015. ORNL DAAC. <https://doi.org/10.3334/ORNLDAAC/1341>

Acknowledgements: This research was performed with support from NASA ABoVE, Grant NNX15AT71A.

2. Data Characteristics

Spatial Coverage: Northwest Territories, Canada

ABoVE Reference Locations:

Domain: Core ABoVE

State/territory: Northwest Territories (NWT), Canada

Grid cells: Ah1v1Bh4v0, Ah1v1Bh4v1, Ah1v1Bh4v4, Ah1v1Bh5v0, Ah1v1Bh5v1, Ah1v1Bh5v2, Ah1v1Bh5v3, Ah1v1Bh5v4, Ah1v1Bh5v5, Ah1v2Bh5v0, Ah2v1Bh0v3, Ah2v1Bh0v4, Ah2v1Bh0v5, Ah2v1Bh1v2, Ah2v1Bh1v3, Ah2v1Bh1v4, Ah2v1Bh1v5, Ah2v1Bh2v3, Ah2v1Bh2v4, Ah2v1Bh2v5, Ah2v1Bh3v5, Ah2v1Bh4v5, Ah2v2Bh0v0, Ah2v2Bh1v0, Ah2v2Bh2v0, Ah2v2Bh2v1, Ah2v2Bh3v0, Ah2v2Bh4v0, Ah2v2Bh4v1

Spatial Resolution: 30 meters and multiple points (field data)

Temporal Coverage: 2014-07-02 to 2016-06-15

Temporal Resolution: One time

Study Areas (All latitude and longitude given in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Northwest Territories, CA	-136.119	-102	71.69472	56.25417

Data file information

There are 60 data files in GeoTIFF (.tif) format with this dataset. This includes one aggregated file for carbon emissions and one aggregated file for

uncertainty across the entire study domain, plus files for estimated carbon emissions and uncertainties for each of the 29 grid cells. The grid locations are included in the file names. Emissions data are provided in units of g C/m².

There is also one file in comma-separated format which provides the field data collected at burned and unburned sites.

The 30-m (B-grid) tiles in the ABoVE grid are the small tiles nested inside the larger (A-grid) 240-m tiles in Figure 2. The first part of the grid cell name refers to the large A-grid, the second part refers to the B-grid. The correct tile is located by first locating the larger grid named **AhAv**, and then locating the smaller tile named **BhBv** within the larger tile. Examples are provided below in the last two file descriptions.

Table 1. File names and descriptions.

File name	Description
Carbon_consumption_domain.tif	One aggregated data file for carbon consumption (g C/m ²) over entire wildfire area.
Carbon_uncertainty_domain.tif	One aggregated data file for predicted carbon consumption uncertainty (g C/m ²) over entire wildfire area.
Carbon_consumption_AhXvX_BhYvY.tif	Carbon consumption (g C/m ²) in the ABoVE tile number AhXvX_BhYvY Example file name: Carbon_consumption_Ah1v1_Bh4v0.tif . This is the upper tile marked with a yellow X in Figure 2
Carbon_uncertainty_AhXvX_BhYvY.tif	Prediction uncertainty of carbon consumption (g C/m ²) in the ABoVE tile number AhXvX_BhYvY Example file name: Carbon_uncertainty_Ah2v1_Bh0v5.tif . This is the lower tile marked with a yellow X in Figure 2
NWT_site_charac_combustion.csv	This file provides burned and unburned plot characteristics, tree basal area and species coverage, soil carbon, moisture, and estimated carbon combustion data. Refer to Table 2. for the variables and descriptions. The plot measurements were collected between June 2015 and June 2016 from burned and unburned sites.

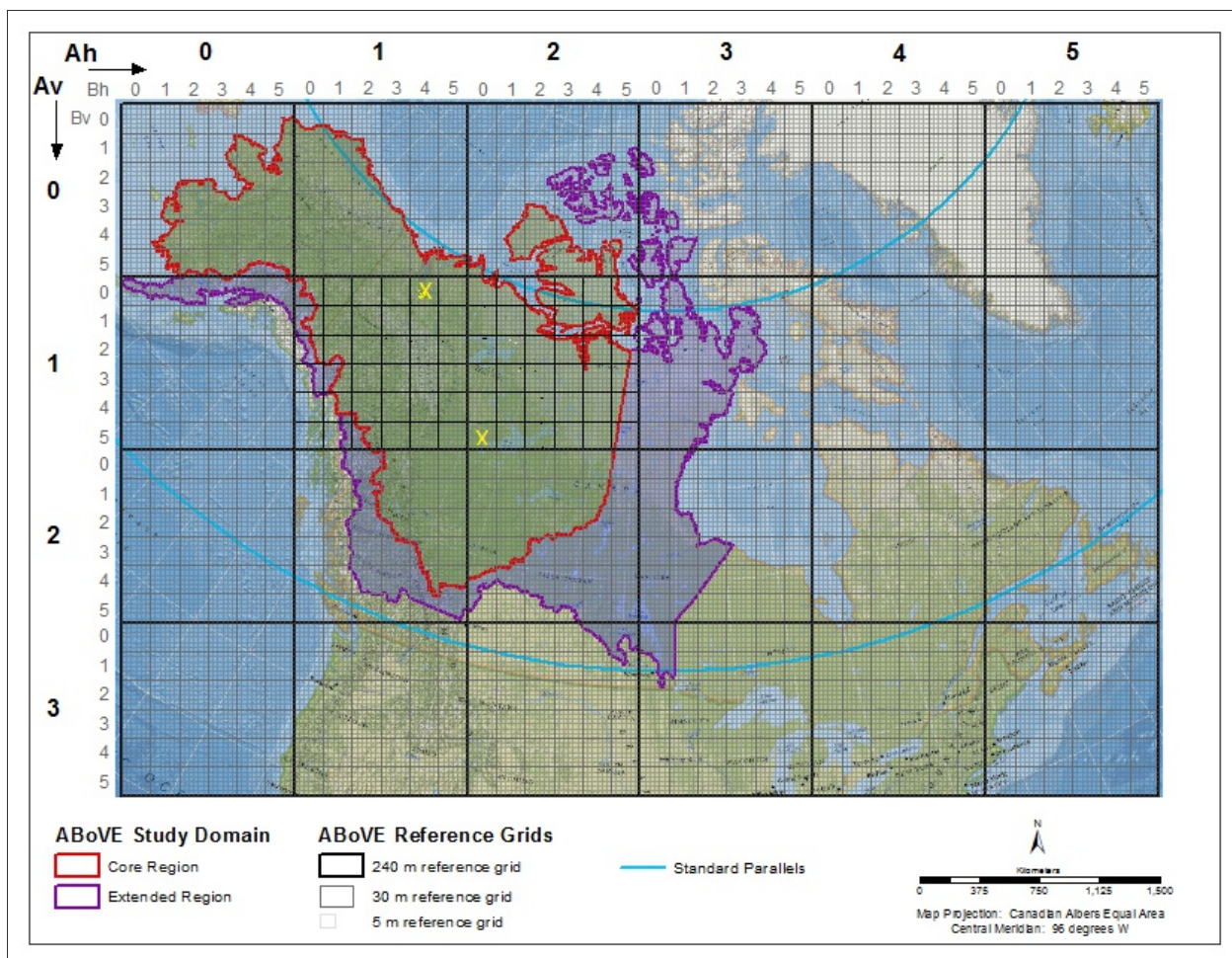


Figure 2. The ABoVE reference grid and study domain. The 240-m reference grid (4,500 X 4,500 grid cells per tile) with associated **Ah** and **Av** values, and the 30-m reference grid (6,000 X 6,000 grid cells per tile) superimposed on the 240-m grid with associated **Bh** and **Bv** values (Loboda et al., 2017). The yellow Xs indicate the tiles from the data files in the examples above.

Table 2. Variables in the file **NWT_site_charac_combustion.csv**

The data are from 211 burned and 36 unburned sites. All measurements were not made at the unburned sites as they did not apply (post fire measurements combustion data, etc). Missing data or data not applicable are recorded as -9999.

Variable	Units/format	Description
site		Site name
plot		Plot name
burn		Name of the Burn Scar or Unburned area (SS33=Kakisa, ZF20=CentralHwy3, ZF46=NorthernHwy3, ZF35=Gameti West, ZF44=Gameti East, ZF26=Wekweeti, ZF104-Discovery Mine, CS= Control Shield, CG1 = Control Group 1, CG2 = Control Group 2)
lat_start	decimal degrees	Latitude at start of west transect from GPS. Datum: WSG84 Position format: hddd.ddddd
long_start	decimal degrees	Longitude at start of west transect from GPS. Datum: WSG84 Position format: hddd.ddddd
burn_year	YYYY	Year plot was burned (2014 or unburned)
ecoregion		Taiga Plains or Taiga Shield
moisture_class		Classification of plot moisture potential using the moisture key presented in the successional trajectories workbook (Johnstone et al., 2008). Classifications are one of xeric, subxeric, subxeric to mesic, mesic, submesic, or subhygric
elev	M.A.S.L.	Elevation at start of west transect from GPS. Meters above sea level
slope	degrees	Slope in degrees. A slope <5 was given a 0
aspect		Slope aspect in compass degrees (0 to 360) - has not been corrected for declination. NA indicates there is no slope >5
org_layer_depth_transect	cm	Mean of organic layer depth (cm) located along the transect (10 points)
org_layer_depth_trees	cm	Mean of organic layer depth (cm) beside trees where adventitious roots were measured (10 points)
adventitious_root_ht	cm	Mean of adventitious root height (cm) - measured on ten trees per plot
basal_area_pinus_banksiana	cm ² /m ²	Total measured basal area (cm ²) of jack pine (<i>Pinus banksiana</i>) expressed on a per m ² basis. Basal area was calculated from stem diameter at breast height or base if less than 1.4m in height (area of each tree= $\pi(\text{dbh}/2)^2$)
basal_area_picea_mariana		Basal area of <i>Picea mariana</i>
density_pinus_banksiana	density per m ²	Estimated density of <i>Pinus banksiana</i> stems per m ² for the pre-fire stand. Sample area was 60 sq. m. All trees and saplings that were alive at the time of the 2014 fires are included
density_picea_mariana	density per m ²	Density of <i>Picea mariana</i>
propotion_picea_mariana		Proportion of <i>Picea mariana</i> in the stand (=density_picea_mariana /total stand density)
proportion_pinus_banksiana		Proportion of <i>Picea mariana</i> in the stand (=density_pinus_banksiana /total stand density)
proportion_other_species		Proportion of other species in the stand
dominant_species		Dominant species (other, pima, or piba)
age_stand	years	Age of stand at time of 2014 fires (years)
The variables below apply to the burned sites only		
agb_prefire	g dry matter/m ²	Aboveground biomass prefire (g dry matter m ²)
agC_prefire	g C/m ²	Aboveground carbon prefire (g C m ²)
agb_combusted	g dry matter/m ²	Aboveground biomass combusted (g dry matter m ²)
agC_combusted	g C/m ²	Aboveground carbon combusted (g C m ²)
burn_depth		Depth of burn calculated by 1) adventitious root height and the associated offset for Pima sites or 2) residual soil organic layer depth subtracted from average unburned organic depth for Piba dominated sites (depending on moisture category).
residual_soil_c	g C/m ²	Residual belowground carbon content (g C m ²)
prefire_soil_c	g C/m ²	Prefire belowground carbon content (g C m ²) Sum of belowground carbon combusted + residual belowground carbon
soil_c_combusted	g C/m ²	Belowground carbon combusted (gC m ²). Based on model of carbon content as a function of depth and depth of burn
total_c_combustion	g C/m ²	Sum of below and above ground carbon combusted (g C m ²)

total_prefire_c	g C/m2	Sum of below and above ground carbon prefire (g C m2)
proportion_total_c_combustion		Total combustion divide by total prefire carbon (0-1)
proportion_soil_c_combustion		Belowground carbon combusted divided by total combustion (0-1)
std_error_soil_c_comb		Standard error associated with estimates of belowground carbon combustion
count_soil_c_comb_std_error		Number of estimates made for belowground carbon combustion for each plot - used for std.error soil combustion calculation
date_of_burn		Date of Burn - pixel-based approach (roughly 500-m x 1-km)
fine_fuel_moisture_code		Fine fuel moisture code - http://data.giss.nasa.gov/impacts/gfwed/
duff_moisture_code		Duff Moisture Code - http://data.giss.nasa.gov/impacts/gfwed/
drought_code		Drought Code - http://data.giss.nasa.gov/impacts/gfwed/
initial_spread_index		Initial Spread Index - http://data.giss.nasa.gov/impacts/gfwed/
buildup_index		Buildup Index - http://data.giss.nasa.gov/impacts/gfwed/
fire_weather_index		Fire Weather Index - http://data.giss.nasa.gov/impacts/gfwed/
vapor_pressure_deficit		Vapor Pressure Deficit - http://data.giss.nasa.gov/impacts/gfwed/
canada_elev_topo_wet_index		Canadian digital elevation - topographic wetness index. http://open.canada.ca/data/en/dataset/7f245e4d-76c2-4caa-951a-45d1d2051333
gruber_ruggedness		Ruggedness Index
dNBR		Clouds masked with cfmask, and dNBR calculated using the median NBR between June 15 and August 31 for both 2013 (pre-fire) and 2015 (post-fire) Google Earth Engine (Landsat 8).
treecover_change_2013_2015		Relative change in Tree Cover from 2013 to 2015 (reference: Sexton et al. (2013))
pct_picea_mariana		Percent composition of Picea mariana; scaled by the fraction of unvegetated land in each pixel. (reference: Beaudoin et al.(2014))
pct_sand_15cm		% sand at 15 cm (reference: Hengl et al.(2017))
Gruber_Ruggedness_v2		Ruggedness Index
pct_picea_mariana_v2	%	Percent composition of Picea mariana; scaled by the fraction of unvegetated land in each pixel. (reference: Beaudoin et al. (2014))
pct_sand_15cm_v2	%	% sand at 15cm (reference: Hengl et al.(2017))
canada_elev_topo_wet_index_v2		Canadian digital elevation - topographic wetness index http://open.canada.ca/data/en/dataset/7f245e4d-76c2-4caa-951a-45d1d2051333
dNBR_v2		Clouds masked with cfmask, and the dNBR calculated using the median NBR between June 15 and August 31 for both 2013 (pre-fire) and 2015 (post-fire). Google Earth Engine (Landsat 8).
treecover_change_2013_2015_v2		Relative change in Tree Cover from 2013 to 2015 (reference: Sexton et al. (2013))

3. Application and Derivation

These data could be useful to wildfire science, climate change, carbon source and carbon sink studies.

4. Quality Assessment

Uncertainties

A Monte Carlo framework was adopted to quantify predictive uncertainty from measurement error in aboveground and belowground combustion, below, and landscape scaling. A total of 1,000 simulations were performed in which inputs varied within a distribution of influential parameters. For aboveground combustion, the percentage C was varied within a normal distribution centered at 50% and a standard deviation of 3%. An overall systematic bias was applied to aboveground combustion (standard deviation of 20%) to account for uncertainty in the visual estimates of consumption, tree diameter measurements, and allometric equations. To account for uncertainty in estimates of belowground combustion, a plot-level systematic bias was applied as above but the standard deviation was defined by the standard error of the mean for each site's belowground combustion, derived from its population of five soil cores. Finally, a new spatial model was derived for each Monte Carlo simulation based on an updated estimate of total combustion in each plot. To account for prediction uncertainty (i.e., error in the model fit), the updated model was applied to each pixel plus a random normally-distributed error term derived from the residual standard errors. The error term was applied to the logarithm of total combustion (which the model was predicting), and subsequently back-transformed into units of combustion (kg C m^{-2}). Because domain-wide mean combustion from these simulations was slightly different than those in our main approach (3% less), all uncertainty estimates were normalized by the ratio of mean combustion estimates.

5. Data Acquisition, Materials, and Methods

Study site

The focus of this study was to develop a high spatial resolution model to scale emissions from fires that occurred in the area near Yellowknife, Northwest Territories, Canada in 2014 (Figure. 3). For this area, the mean annual temperature was -4.3°C and mean annual precipitation was 290 mm

from 1981-2010. The study area covers portions of two ecozones, the Taiga Plains and Taiga Shield, which differ in their geological history, soils development and parent materials. Black spruce forests dominate the fine-textured, glacio-lacustrine soils found in both ecozones, while jack pine is dominant on the coarse, alluvial and glacio-fluvial soils. Low density black spruce and jack pine typically dominate the exposed bedrock characteristic of the Taiga Shield.

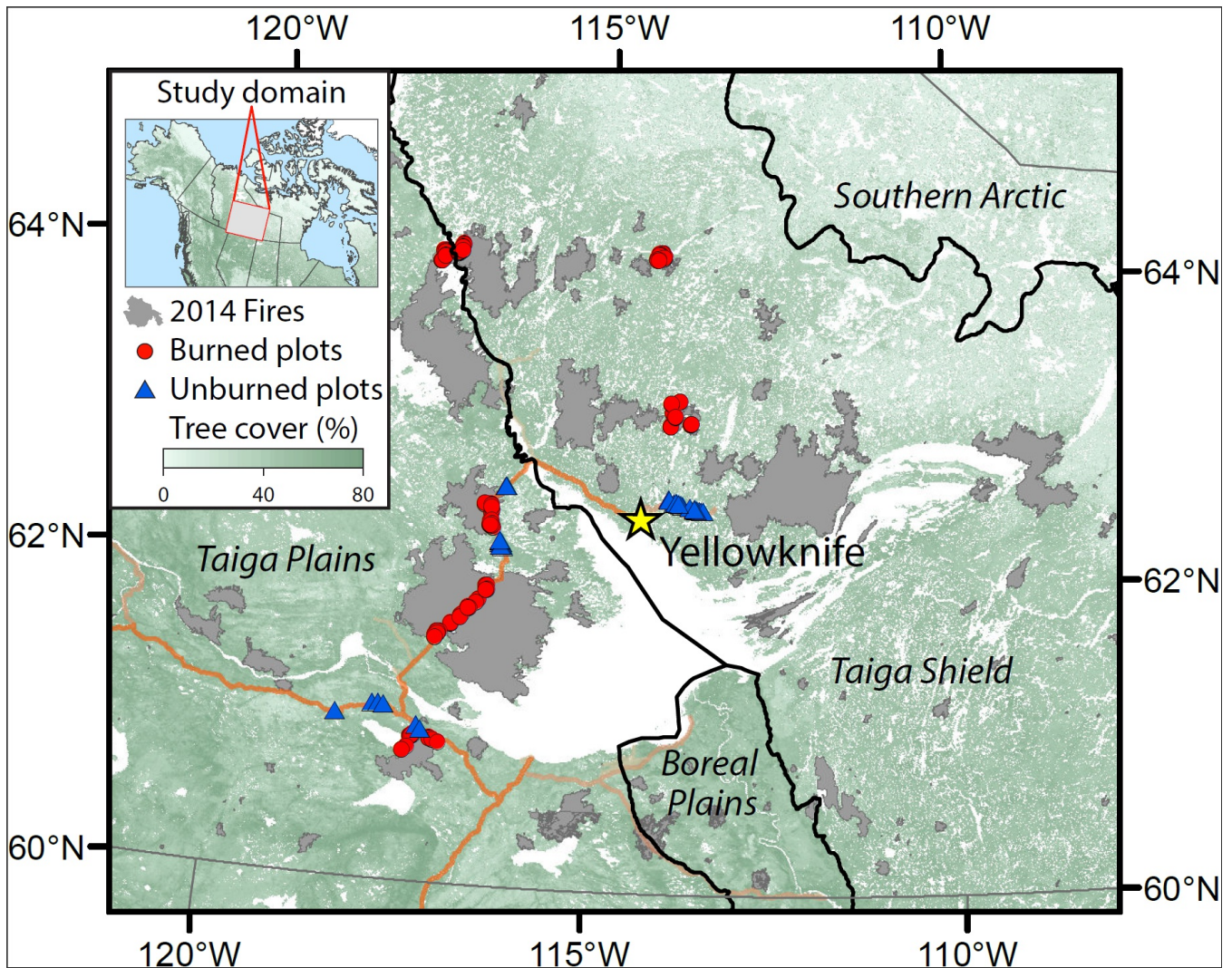


Figure 3. Map of study area.

Field Methods

Burned areas:

Field data from burned plots, including measurements necessary to calculate carbon emissions as well as properties that influence combustion, were collected between June and August of 2015 in seven spatially independent burn scars, four in the Taiga Plains ecozone and three in the Taiga Shield ecozone, which had burned between June and August 2014. Within each burn, random sampling points were identified based on stratum of conifer density identified by the Land Cover Map of Canada 2005, produced from 250-m Moderate Resolution Imaging Spectroradiometer (MODIS) imagery (Latifovic et al., 2004), date of burn (early, mid, late season), and whether a plot was a “reburn” based on fire history information. Where Forest Resource Inventory data were available the leading tree species (black spruce or jack pine) was also identified. For ease of access the random sampling points were constrained to be within 1-km of highways or lake shorelines. Three to 12 random points (‘A’ plots) were located within each conifer density stratum or leading tree species (black spruce or jack pine) for each burn. Moisture classes, based on topography-controlled drainage were assessed and adjusted for soil texture and presence of permafrost for each random point on a six-point scale, ranging from xeric to subhygric, using the method outlined by Johnstone et al., (2008). In addition, at least one, but usually two, other points (‘B’ and ‘C’ plots) were identified that were of a different moisture class and within 100-500 m of the random point. A site was defined as the combination of the random plot and these additional plots. A total of 211 burned plots nested within 78 randomly located sites were sampled (Walker et al., 2018).

Unburned areas:

In June of 2016, field work was conducted in three spatially independent areas of forest, two in the Taiga Plains and one in the Taiga Shield (Fig. 3), that had no history of fire since records began in the NWT, in 1965. The selection procedure for unburned plots was designed to ensure they best matched conditions at burned plots. For 36 randomly selected burned plots, 30-m unburned sampling locations were subset by those that had the same aspect quadrant (N, E, S, W, or flat), based on the Canadian Digital Elevation Model (CDEM, <http://www.geobase.ca>), and that had pre-fire tree cover (Hansen et al., 2013) within $\pm 2\%$ of the burned plot. Plots were selected that most closely matched the slope of the given burned plot based on the CDEM (Walker et al., 2018).

At each plot we recorded latitude, longitude, and elevation with a GPS receiver, and slope and aspect with a clinometer and compass. Each plot consisted of two 30-m parallel transects that were 2-m apart. Transects ran due north.

Field measurements:

Soil measurements were made along both transects within each plot. In burned and unburned stands, soil organic layer (SOL) depth was measured every six m (10 points/plot). The top 15 cm of the SOL profile were collected to assess soil C in unburned plots or the entire residual SOL profile in burned plots, at five points per plot along one transect. An intact sample of the SOL of approximately 5-cm x 10-cm was collected using a serrated knife and

pruners. Dimensions of each SOL sample were recorded in the field. Organic samples were immediately frozen until they could be processed in the lab. In addition to the ten SOL depth measurements, the SOL depth was measured near the base of ten trees per plot for burn depth calibrations. At these points, the SOL depth was measured as close to the tree as possible. In association with these points, the depth from the top of the green moss to the closest adventitious root was measured on 1-3 adventitious roots per tree in unburned stands, and the height from the highest adventitious root height (ARH) to the top of the residual SOL on 1-3 adventitious roots per tree in burned stands.

In each plot, the basal diameter of trees < 1.3 m tall that were originally rooted within a 2-m x 30-m belt transect was measured. Fallen trees that were killed by fire were included in this census. Tree combustion was assessed where each tree was ranked from 0 to 3; 0=none, alive and no biomass combusted; 1=low, only needles/leaves consumed; 2=moderate, all foliage and majority of fine branches combusted; 3=high, most of the aboveground canopy including foliage, branches, and bark combusted. To estimate stand age, five tree disks were collected in burned stands or five tree cores in unburned stands from each of the dominant tree species within a stand, either black spruce, jack pine, or both species.

Laboratory Methods

Soil bulk density and carbon (C) content in relation to depth was assessed from 507 samples from 137 monoliths collected in 36 unburned plots and 1076 samples from 345 monoliths obtained from 134 burned plots.

Tree disks and cores were processed using standard dendrochronology techniques (Cook et al., 1990) and tree rings were counted as an estimate of time since last fire (see Walker et al., 2018(b) for details).

Stem counts, diameter, measurements and published allometric equations (Lambert et al., 2005) were used to calculate tree density (number stems m^{-2}), basal area ($m^2 ha^{-1}$), and aboveground biomass (kg dry matter m^{-2}) of the total tree, bark, main branches, fine branches, and needles/leaves, for each tree species in each plot. Total tree biomass combusted was calculated per tree from the assigned combustion class and affected biomass components (foliage, branches, and bark). Individual tree estimates were summed and divided by the sample area to estimate pre-fire biomass and biomass combustion (kg dry matter m^{-2}) per plot. A biomass C content of 50% was assumed.

The adventitious root method and calibrations described in Walker et al., (2018) was used to calculate depth of burn in black spruce dominated stands. Total depth of pre-fire SOL was then reconstructed by adding the ARH and the associated offset to the residual SOL depth. In jack pine dominated plots, where ARH measurements were not possible, depth of SOL combustion was assessed by subtracting the residual SOL from the unburned average SOL depth associated with each moisture category (see Walker et al., 2018 (b)).

Soil C content model development

Soil carbon content was modeled as a function of depth using soil monoliths from unburned and burned plots. For each soil monolith (n=534), the cumulative sums of carbon content by 5 cm depth increments (n=1518) were calculated starting from the surface, which was 0 cm in unburned plots, but was adjusted according to burn depth in burned plots. Monoliths from both burned and unburned plots were used to ensure that the full range in SOL depths was captured. Linear mixed effects models were fit with a hierarchical random effects structure of soil monolith nested within plot, nested within unburned area or burn scar. Separate models were fit for black spruce and jack pine dominated plots. The full models included covariates for depth, ecozone, and moisture category, and their first order interactions. Model reduction was completed through backward selection using likelihood ratio tests of the full model against the reduced models.

The models specific to each forest type were used to predict the carbon content (kg C m^{-2}) of both combusted (based on burn depth) and residual SOL for 10 measurements per plot. Pre-fire SOL carbon pools were calculated by summing the residual and the combusted carbon pools, which were then averaged per plot. For subsequent analysis we used the measured residual SOL carbon pool from the 134 plots for which direct measurements were made and the predicted SOL carbon pool from the remaining 77 plots.

Calculated carbon combustion

Three measures of carbon combustion were calculated for each plot: 1) total carbon combusted as the sum of above and belowground C combustion, 2) proportion of pre-fire C combusted as total C divided by the total pre-fire carbon, and 3) proportional of total C attributed to the soil organic layer as belowground C combustion divided by total C. Plot attributes were examined associated with fuel and weather conditions on the day of burning (Table 3). Refer to Walker et al., 2018(b) for additional details.

Table 3. Covariates included in each of the candidate models to predict total carbon combusted, total carbon combusted relative to total pre-fire carbon, and the proportion of soil carbon combusted relative to total carbon combusted.

Model	Variables
Null Model	None
M1: Plot-level attributes	Moisture class Elevation Stand age Latitude
M2: Pre-fire Stand Composition	Black spruce proportion Total above ground biomass
M3: Fire Attributes	Date of burn Fine Fuel Moisture Code Drought Moisture Code
M4: Plot-level attributes + Pre-fire Stand Composition	M1 + M2
M5: Plot-level attributes + Fire Attributes	M1 + M3
M6: Pre-fire Stand Composition + Fire Attributes	M2 + M3
Full Model	M1 + M2 + M3

Spatial modeling

A model was derived using only covariates obtainable from geospatial layers that covered the entire spatial domain of interest. Initially, 71 spatial layers were considered that were associated with topography, permafrost condition, fire severity, tree cover, peatland cover, date of burn, fire weather, tree

species biomass and percent cover, and soil properties. Values for each plot were extracted using weighted averages of relevant pixels covering our 2 x 30-m transects. Model reduction was completed through backward stepwise election using likelihood ratio tests of the full model against the reduced models. For the minimum adequate model, residual plots were examined to test for heteroscedasticity and non-normality. For prediction purposes, the model's expected values were back-transformed from a log to a natural scale assuming a log-normal distribution (i.e., accounting for bias in the mean estimate), resulting in a multiplicative nonlinear regression model.

The final model was used to estimate total C emissions at 30-m resolution across all fires in the 2014 NWT fire complex. First, burned pixels were estimated such that a pixel was defined as burned if it was defined as land according to the Sexton et al. (2013) tree cover database, was contained in the Canadian National Fire Database (Canadian Forest Service, 2017), and had a dNBR value of at least 0.1. However, not all land pixels had valid dNBR values, and an estimated total burned area was provided for the 2014 NWT complex by summing the area of pixels defined above with those that were not covered by our dNBR dataset but had valid land pixels within the fire perimeters, multiplied by the fraction of pixels that exceeded our 0.1 dNBR threshold within fire scars.

To apply the model across all fire perimeters, final model covariates were re-gridded to a common 30-m grid and Canadian Albers Equal Area Conic projection (bilinear interpolation for datasets coarser than 30-m and nearest neighbor for datasets 30-m or finer), defined by 29 tiles within the ABoVE 30-m reference grid (Figure 2). For consistency, the regression model was re-run with these downscaled covariates. The regression model was then applied to burned pixels defined by a threshold of Landsat-derived differenced Normalized Burn Ratio (dNBR) within fire perimeters. To limit unreasonably high combustion estimates, a maximum cap was applied on emissions of 1.2 times the maximum combustion observed at our field sites (9.26 kg C m⁻². Note this only applied to 0.02% of pixels). To provide an estimate of total emissions from the 2014 NWT complex, the estimate of total emissions was scaled to the complex considering the fraction of burned area not covered by our model (4%), assuming mean combustion in the missing burned pixels (Walker et al., 2018).

Uncertainties

A Monte Carlo framework was adopted to quantify predictive uncertainty from measurement error in aboveground and belowground combustion, below, and landscape scaling. A total of 1,000 simulations were performed in which inputs varied within a distribution of influential parameters. A new spatial model was derived for each Monte Carlo simulation based on an updated estimate of total combustion in each plot.

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

[ABoVE: Wildfire Carbon Emissions and Burned Plot Characteristics, NWT, CA, 2014-2016](#)

Contact for Data Center Access Information:

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