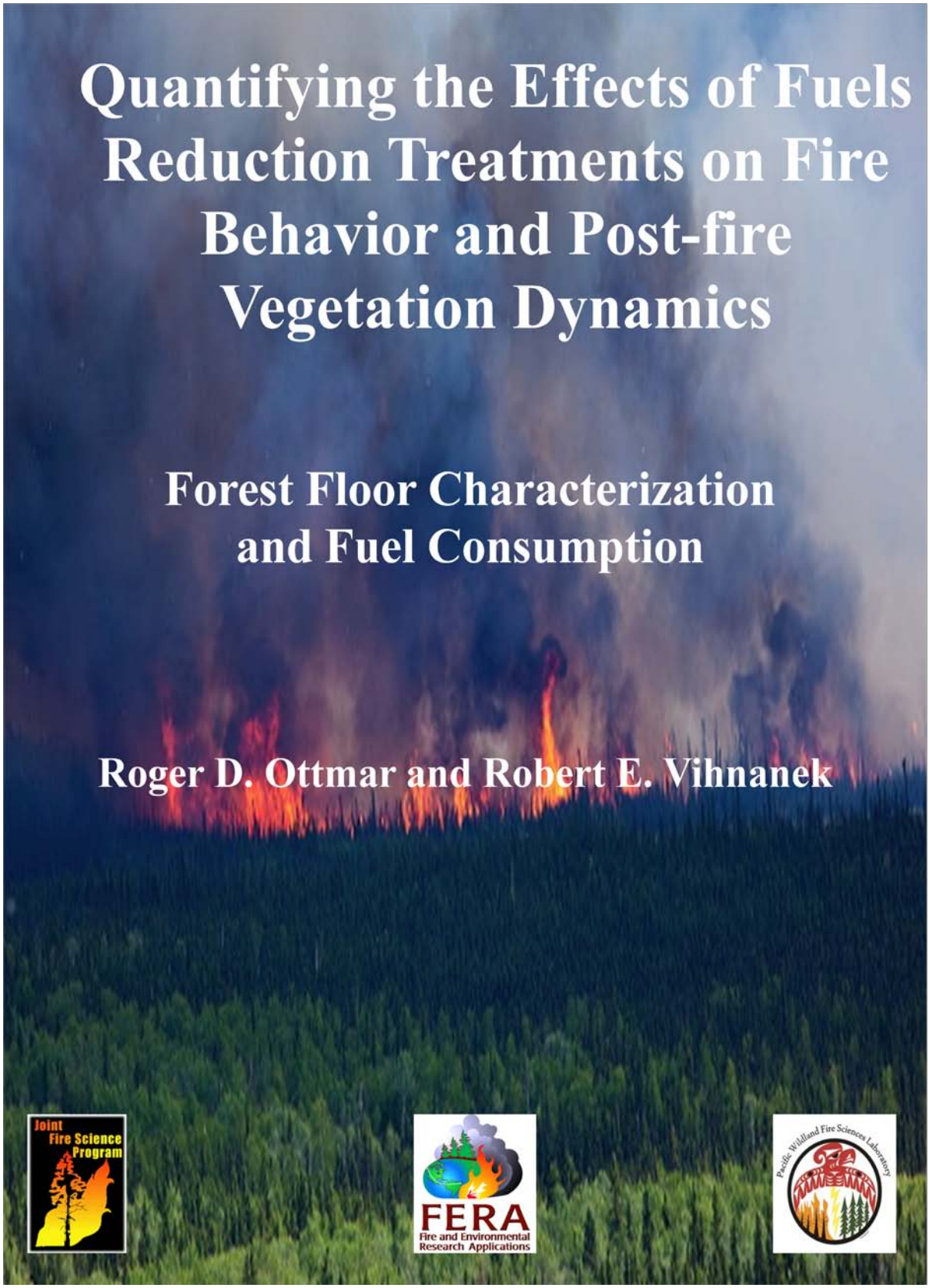

Quantifying the Effects of Fuels Reduction Treatments on Fire Behavior and Post-fire Vegetation Dynamics

Forest Floor Characterization and Fuel Consumption

Roger D. Ottmar and Robert E. Vihnanek

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Abstract

Several fuel treatment options are available for reducing fire hazard in the boreal forests of Alaska. Although the effectiveness of each treatment is consistently demonstrated in reduced wildfire acreage and damage, quantification of the degree of hazard reduction effectiveness is not known. This paper describes the characterization and consumption of the forest floor during a large study supported by the Joint Fire Science Program (JFSP) to demonstrate the effectiveness of common fuel treatment options available to land managers in Alaska. Sixteen plots with 16 forest floor consumption pins were systematically positioned within the perimeter of a thinned and piled and burned treatment block located in a spruce forest near Fairbanks, Alaska. Sixteen plots were also positioned outside the treatment block as a control. A stand replacing prescribed fire was initiated that burned through the treatment block in the summer of 2009. Nearly 100% of the forest floor consumption pins located in the control plots burned while only 25% of the pins burned within the treatment area. Assessing only pins that burned, forest floor depth reduction was 5.8 cm for the control and 5.4 cm for the treatment block. Assessing all pins, forest floor depth reduction was 5.8 cm for the control plots and 1.2 cm for the treatment area. Although only one treatment block was burned in this study, observations indicate the thinning and pile and burn treatment may have reduced the area that was available to burn and consume the forest floor. Comparing the percent consumption of all pins burned with predictions from Consume, Consume 3.0 under-predicted the measured forest floor consumption by 4% for both the treated and control plots.

Introduction

Fuel treatment options such as thinning followed by piling and burning, shearblading, and prescribed fire are used for fire hazard reduction in the boreal forests of Alaska. Although the effectiveness of the treatments are consistently demonstrated in reduced wildfire acreage and damage, quantification of the degree of hazard reduction effectiveness is not known which is critical for fuel planning and efficient use of resources. To demonstrate the effectiveness of fuel treatment options used in Alaska, the Joint Fire Science Program (JFSP) supported a research project to prescribe burn a large spruce forested area with various fuel treatment options. These options included 1) 2.4 x 2.4 m thinnings pruned to 1.2 ft under three different fuel removal strategies: (1) haul away, (2) burn piles on site, and (3) windrow and burn on site and 2) four shearblading treatments; with and without windrowing of debris and with and without pile burning. The Fire and Environmental Research Applications Team (FERA) of the Pacific Northwest Research Station Pacific Wildland Fire Sciences Laboratory led an aggressive field effort to gather forest floor depth and consumption data to support the other science disciplines participating in the study and to provide a valuable data set for validation of boreal forest fuel consumption models such as Consume (Ottmar et al. 2005)

Methods

Sixteen forest floor depth and consumption plots were systematically located inside and outside each of the A1, A2, B3, and B4 thinned treatment blocks established for the study (Fig. 1). Forest floor reduction was measured as the dependent variable according to procedures adapted from Beaufait et al. (1977). Within each plot, 16 forest floor pins were inserted 0.5 meters apart into the forest floor and clipped flush with the lichen, moss, or duff surface (Fig. 2). Because the forest floor is often very deep, lightweight welding rod >60 cm in length was used as forest floor reduction pins. No data was collected on the pre-burn loading or consumption of the shrub, grass and woody fuels because very little mass existed of those fuelbed categories.

Forest floor layer depths and fuel moisture content were measured as independent variables. Four forest floor plugs approximately 10 cm^2 was removed from near each plot and the depth of the live moss, dead moss, upper duff, and lower duff was measured (Fig. 3). Just prior to the burn, a final plug was collected to determine fuel moisture content, separated into live moss, dead moss, upper duff, and lower duff categories and placed into labeled and sealed plastic bags. All samples were oven dried at 70 °C for 96 hours and weighed before and after drying to determine fuel moisture content by forest floor category.

After the smoldering combustion was complete, each plot was relocated, and the depth of the burn was measured at each forest floor reduction pin (Fig. 4). A measurement from the top of the pin to mineral soil provided a total forest floor depth. All data was input into the FERA Data Reduction and Analysis Program (DRA) to summarize the mean, median, standard deviation, and standard error of the fuel moisture contents by fuelbed categories, pre-burn forest floor depths by forest floor layer and forest floor consumption by layer.

A standard Fuel Characteristic Classification System (FCCS) (Ottmar et al. 2007) fuelbed representing a boreal forest spruce stand that closely matched the Nenana site was customized

with measured forest floor depths. The custom fuelbed was imported into Consume and measured weather variables and fuel moisture contents were entered. Consumption was predicted and compared to measured forest floor consumption.

Results

Only the A1 treatment and control blocks burned during the stand replacement prescribed fire. Consequently, the independent variables of forest floor pre-burn depth and moisture content, and the dependent variable of forest floor depth reduction, and fuel consumption are reported only for the A1 treatment and control areas. The forest floor moisture content for the A-1 treatment area averaged 36 % for the live moss, 105 % for the dead moss, 183 % for the upper duff and 247 % for the lower duff (Table 1). The moisture content of the dead grass was 9.3 %, live grass, 293%, and the shrubs, 93 %. Black spruce needle fuel moisture was 151 %. If we consider all 256 pins in the A1 treatment block, regardless if the pin burned or not, the preburn depth was 21.8 cm with a forest floor reduction of 1.2 cm. If we consider only the 60 pins that burned, the preburn forest floor depth was 23.9 cm with a forest floor reduction of 5.4 cm (Table 2).

The forest floor moisture content for the control area averaged 92% for the live moss, 193 % for the dead moss, 132 % for the upper duff and 163 % for the lower duff. Moisture content of the shrub was 93 % while the live black spruce needles were recorded at 95 % (Table 1). No moisture samples were collected for the live and dead grass. Of the 256 forest floor pins located outside the A1 treatment area (control), 249 burned with a pre-burn depth of 24.9 cm and a forest floor reduction of 5.8 cm (Table 2).

Consume 3.0 predicts boreal forest floor consumption using an empirically derived model developed from a set of boreal forest floor consumption data collected between 1990-2004 (Ottmar et al. 2005). Using only the pins that burned, lower duff moisture, and preburn forest floor depths, Consume 3.0 under predicted the measured forest floor consumption by 4% for the treatment block and by 7% for the control (Table 2).

Discussion

Since only one treatment area burned during this research project, it is difficult to state any specific scientific conclusions. However, there are interesting observations that can be used as anecdotal evidence from this experiment. For example, the fire burned 99% of the forest floor consumption pins located in the control plots outside the A-1 thinned treatment area. This is compared to only 25% of the pins burned within the treatment block (Fig. 5). Is the reduced number of pins burned due to the thinning treatment and subsequent fuel removal? Perhaps this is the case. However, our N=1 does not support this conclusion statistically, only as anecdotal evidence. We hope to complete the remaining burns in 2012 and provide two additional treatment areas to add to the data set. Although we cannot state a scientific conclusion on one treatment site, we can use these data to validate current forest floor consumption models. The 4 to 7 percent under-prediction of consumption by the model compared to the measure forest floor consumption is within the error bounds of Consume (Ottmar et al. 2005).

If we can obtain tree densities and grass and shrub characteristics for the A-1 treatment and control areas, we can build FCCS fuelbeds and calculate FCCS surface and crown fire potentials and surface fire behavior reaction intensities, flamelengths, and rates of spread. These values could be compared with observations and measurements made by the fire behavior research group and used to validate the FCCS.

Literature Cited

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Tables

Table 1. Fuel moisture content by fuelbed categories before the burn.

Table 2. Preburn depth and reduction of the forest floor and forest floor consumption predictions from Consume.

Table 1.

	Fuel Moisture Content (%)							
Unit	Live needles	Live grass	Dead grass	Shrub	Live moss	Dead moss	Upper duff	Lower duff
A-1 Treatment	151	293	9.3	92.6	36	105	183	247
A-1 Control	95	Not sampled	Not sampled	161	92	193	132	163

Table 2.

Unit	Pins placed (#)	Pins analyzed (#)	Pins burned (#)	Preburn depth (cm)	Preburn depth SE (cm)	Postburn depth (cm)	Postburn depth SE (cm)	Depth reduction (cm)	Consumption (%)	Consume prediction (%)
A-1 Treatment[1]	256	254	60	21.8	0.23	20.6	0.10	1.25	6	19
A-1 Treatment[2]	256	60	60	23.9	0.24	18.5	0.09	5.4	23	19
A-1 Control[3]	256	249	256	24.9	0.12	19.1	0.12	5.8	23	16

[1]Two pins were lost or stepped on and were eliminated from the analysis.

[2]Only pins that were burned were analyzed.

[3]Seven pins were lost or stepped on and were eliminated from the analysis.

Figures

Figure 1. Treatment block and control forest floor characterization and consumption plot layout.

Figure 2. Individual forest floor and consumption plot layout.

Figure 3. Forest floor profile showing the live and dead moss, upper and lower duff layers.

Figure 4. Post fire inventory of forest floor consumption.

Figure 5. Burned area in A1 treatment block.

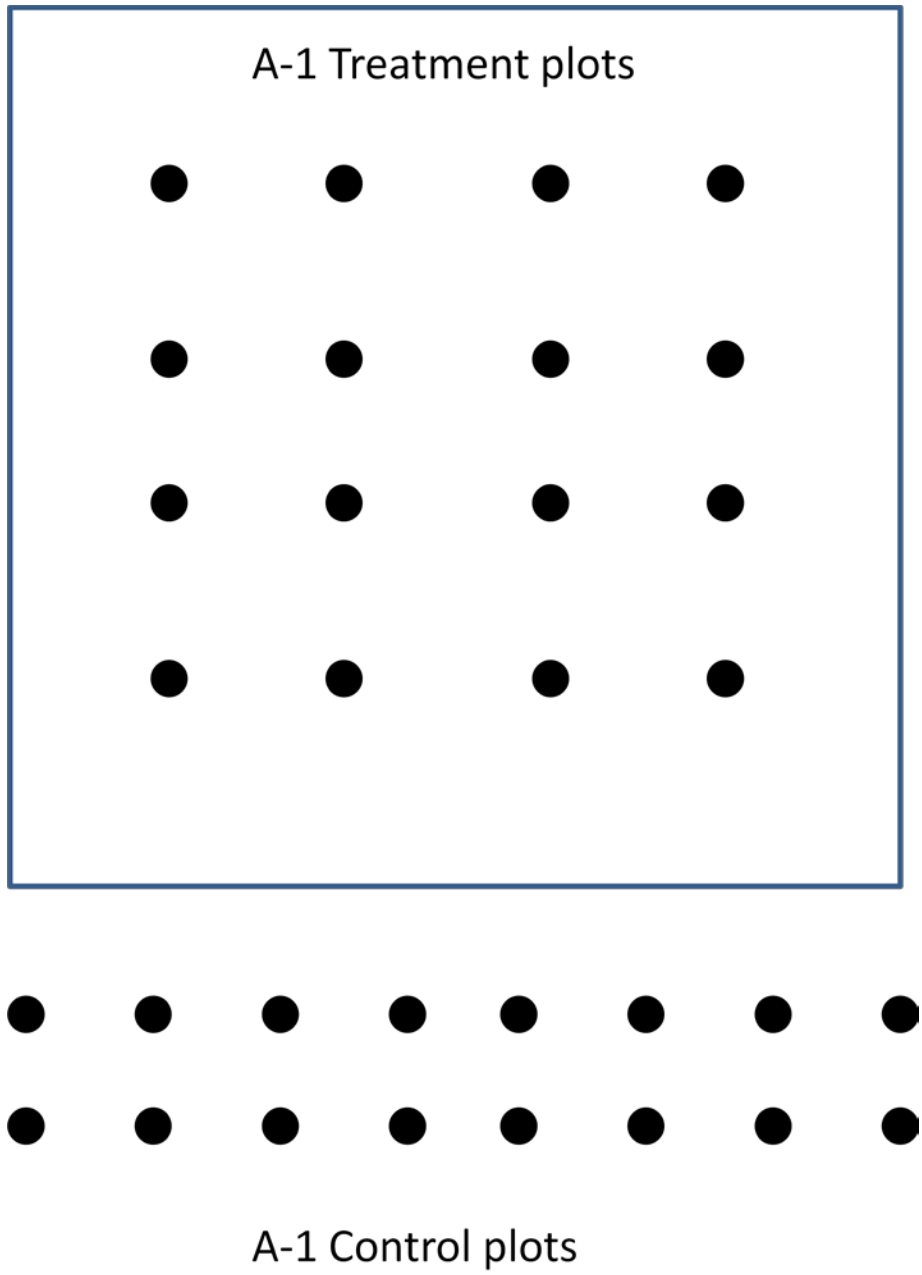

Fig. 1

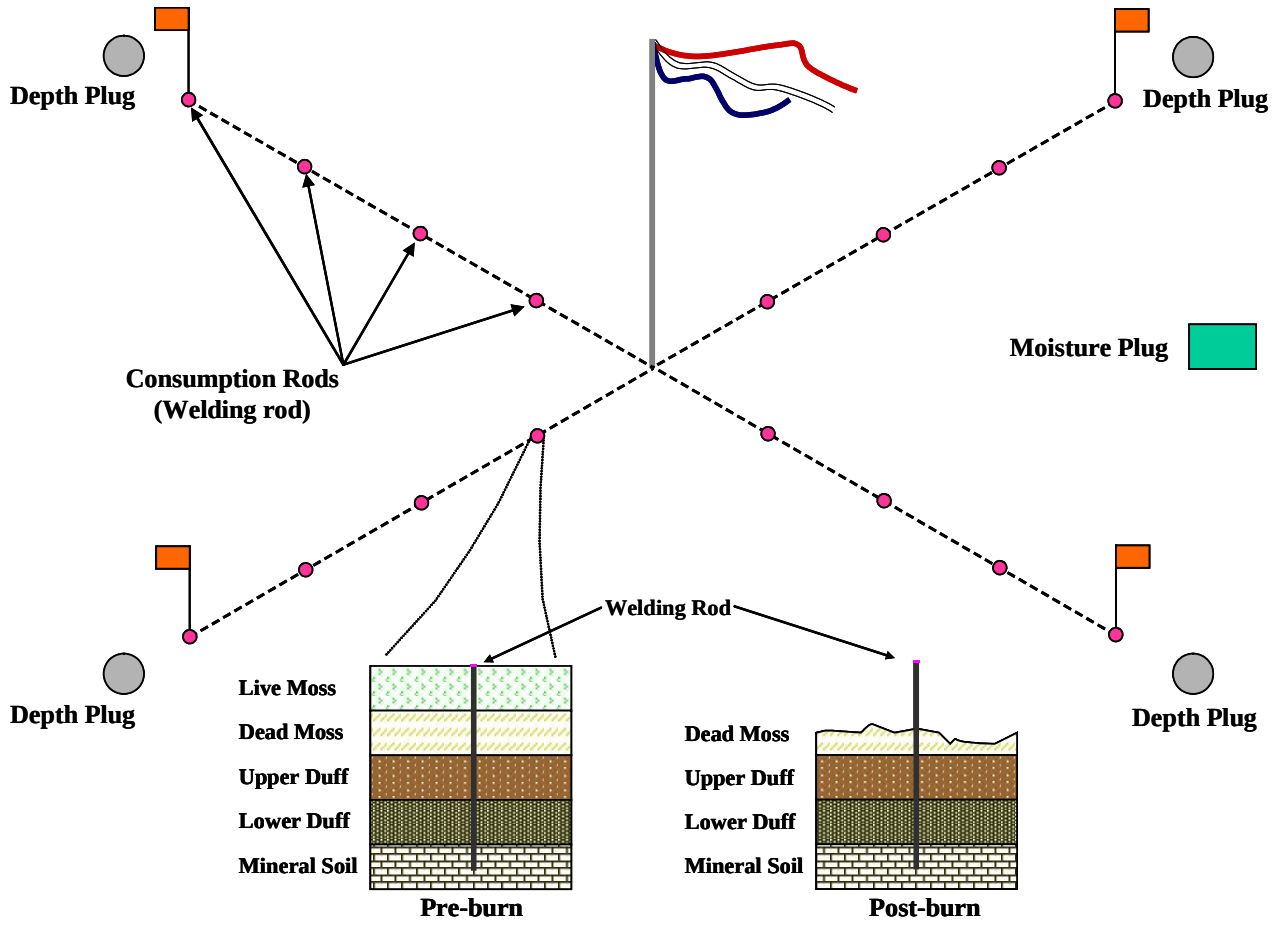
Depth Plug
Depth Plug
Consumption Rods
(Welding rod)
Moisture Plug
Welding Rod
Depth Plug
Depth Plug
Live Moss
Dead Moss
Upper Duff
Lower Duff
Mineral Soil
Pre-burn
Dead Moss
Upper Duff
Lower Duff
Mineral Soil
Post-burn

Fig. 2.

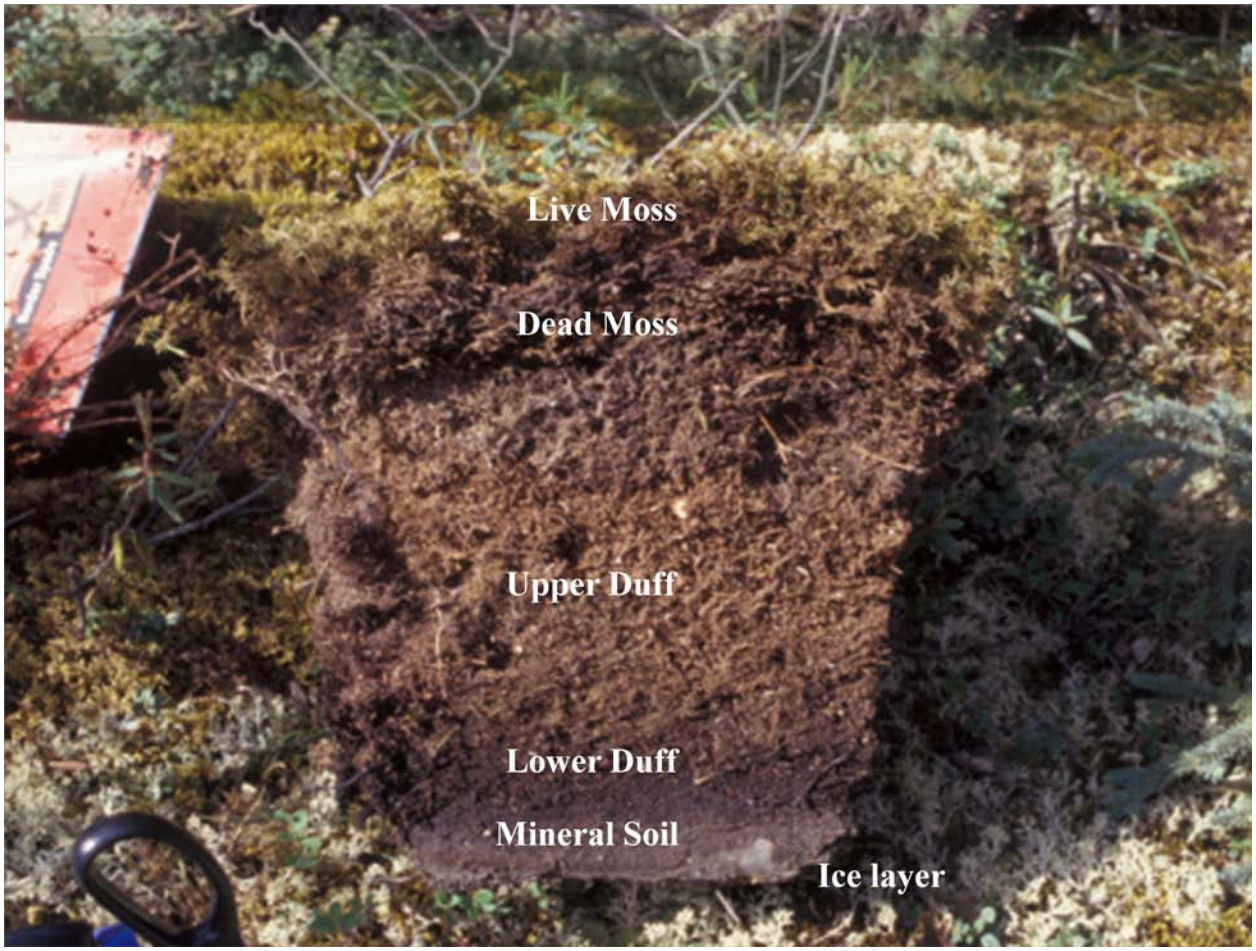
Live Moss
Dead Moss
Upper Duff
Lower Duff
Mineral Soil
Ice layer

Fig. 3

Fig. 4.

Fig. 5.