Response to Reviewer 1

(line numbers refer to original manuscript/current manuscript)

line 3/3: I suggest reformulating the sentence "Boreal soils […] organic soils. *I tried rewriting this sentence several times and have a hard time rewording it as suggested so I am leaving the text as it was.*

Line 4/36: Is there a difference between "layers" and "horizons"? You use both terms throughout the entire manuscript. I suggest you define that in the methods or stick to one of these expressions. *Layers and horizons are the same thing. This is now clarified in line 36. In addition, the text of the manuscript was changed so that horizon is consistently used throughout.*

Line 16/16: Please reformulate the sentence "These soils [….] organic soil layer. *Sentence simplified.*

Line 22/22: Please better link the last sentence of this paragraph to the rest of the paragraph or highlighting the importance of it. *A sentence has been added to link the last sentence to the rest of the paragraph: "Thus, both organic and mineral soil play an important role determining the amount of C stored in boreal ecosystems."*

Line 24/24: Please add a source for the first sentence of the paragraph. *Reference added. In addition, the text of this entire paragraph has been strengthened and additional references have been added.*

Line 24/n.a.: Replace "is" with "are": *This text no longer exists (see previous point).*

Line 30/36: layers or horizons? *This issue is now corrected (see line 4 response).*

Line 35/41: I suggest writing "C and N" instead of C/N. This might be misleading. C/N is often understood as C:N ratio. *This entire sentence has been rewritten so this request no long applies (see next response).*

Line 36-48/41-62: I suggest writings "Fires affect…"; I suggest replacing "several" with "multiple"; "First" but where is the second and third in this paragraph. Please restructure the paragraph and make it more clear, which are the several ways boreal soils are affect by fire; I suggest reformulating "the amount of which". *This paragraph is now rewritten with these comments incorporated and now reads:*

> The main disturbances that affect boreal soil properties are fire and permafrost thaw. Fires affect boreal soils through the combustion of litter and surface organic layers (as ground fuel; Harden et al., 2000), with the amount and depth of combustion regulated by fire severity (Turetsky et al., 2011). Fire directly effects surface organic soils, both in elemental composition and structure (Neff et al., 2005). In addition, there are indirect effects of fire on soil properties. The loss of insulating organic soil results in a darkened soil surface, which in turn warms post-fire soils, increasing decomposition rates from the surface downward (Genet et al., 2013; O'Neill et al., 2002). In addition, both fire return interval and fire severity influence post-fire vegetation and the re-accumulation of organic soil layers. As different tree and understory species have different amounts of C and N in their tissues (Van Cleve et al., 1983), changes in post-fire vegetation affect soil C and N accumulation rates and thus, the concentration of these elements in surface soil. Permafrost thaw also affects soil properties in several ways. By definition, thaw exposes older, previously sequestered C to warmer soil temperatures (Osterkamp et al., 2009),

> increasing rates of decomposition (Mu et al., 2016; Schadel et al., 2016). In well drained sites post-thaw conditions usually result in water draining from the soil, resulting in oxic conditions (Estop-Aragonés et al., 2018). In lowlands, permafrost thaw often results in subsidence and inundation, changing the ecosystem from a forested permafrost plateau to a thermokarst wetland (Schuur et al., 2015). Fire can often be a trigger for this rapid permafrost thaw (Myers-Smith et al., 2008). Post fire vegetation changes affects both C and N inputs, again affecting the concentration of these elements within surface organic soil layers. As both fire frequency and permafrost thaw are expected to increase in the future (Hinzman et al., 2005), biogeochemical models have a need to characterize how these disturbances will impact C and N stocks. To accurately represent future scenarios, models need to include the distinct properties of organic soil horizons found in the boreal region (Flato et al., 2013).

Line 41/49: How does post-fire vegetation affect the chemistry of C and N inputs to the soil? Please add another sentence of give an example. *This paragraph is now rewritten, with this issue addressed. Please see above response.*

Line 47-48/58-60: This is a hard transition from these two paragraphs. Please try to better link these paragraphs: *This paragraph is now rewritten, with this issue addressed. Please see above response.*

Lines 52/71: I suggest writing “more than 3000 observations” instead of “> 3000 observations”. *Wording changed.*

Line 62/79-87: I suggest adding a sentence over which time period the samples were collected. Could you add information on the depth of sampling? How many locations and sites were sampled? In the data set I find 57 different locations with coordinates but in chapter 3.7 it is written that more than 290 soil profiles were sampled. Please state that in the text. *The beginning of the field methodology section now gives details on the number of sites, cores, and profiles taken as well as discusses the depth of sampling. This paragraph now reads*

> Soil cores were sampled at 58 different sites located within several areas of Interior Alaska (Figure 1). Several different ecosystem types were sampled, including black spruce forests (~50%); wetlands (~26%); and deciduous and mixed forests (~16%). Between 1 and 14 soil profiles were sampled at each site, for a total of 292 soil profiles. Sampling took place over a 15-year period from 2000-2015. We examined the effect of fire or permafrost thaw disturbance on soil properties by categorizing each of the soil profiles in relation to time since the last disturbance, which we divided into three age classes: new (<5 yrs old), young (5 – 50 yrs old), and mature (> 50 yrs old). All new sites were recently burned and thus had lost some portion of their surface organic horizons (Harden et al., 2000), while young sites experienced either fire or permafrost thaw.

Line 77/130: I suggest naming this classification as Table 1. *This information is now included as a table. In addition, we added more text to Table 1 to expand upon these definitions. The manuscript gives very brief descriptions of the six main horizons: “A description of the horizons and the codes we used to represent them are found in Table 1, but in summary there are six main horizons: live moss (L), dead moss (D), fibric (mostly undecomposed; F), mesic (more decomposed; M), humic (very decomposed; H), and mineral soil (Min).”*

Line 93-94/132-134: The references here are basically the same, just different editions. I suggest choosing one and naming it Soil Survey Staff (1993) in the reference. *One of these references is for the US systems, while the other is for a Canadian manual so both references are still included. The references have been fixed in the citation program to provide the entire author name, making this fact clear.*

Line 98/94: I suggest replacing “in that” with “because”. *We prefer the original wording.*

Line 101/98: Redoximorphic – check the spelling. *Spelling corrected*

Line 136/175: “In the field the best call was made to if it was…” I suggest re-writing this sentence something like “in the field visual inspection of the soil samples gave a first indication.” *Rewritten as “Using visual and textural cues the field, horizons were categorized as either mineral (< 20 % C) or organic (≥ 20 % C).*”

Line 140/180: Please add “R core Team” to the source. Also, I could not find this reference in the reference list. *This reference was included, but the way in which it was entered into the citation program had it appearing as ‘Team, RC’. This citation is now fixed.*

Line 142/183: Please add “for significant differences among the different soil horizons” after “was tested”. *Verbiage added.*

Line 169/208: Please write “were not” instead of “weren’t”. *Sentence rewritten changed.*

Line 178/223: “likely due in large…” I suggest rephrasing this sentence. *Wording changed.*

Line 204/250: I suggest naming this sub-chapter “soil horizon thickness”. *Heading title changed.*

Line 215/262: Please write “was not” instead of “wasn’t”. *Wording changed.*

Line 216/263: Please write “it is” instead of “it’s”. *Wording changed.*

Line 222/270: I suggest adding another main chapter for the two subchapters 3.7 and 3.7 since it is more a discussion chapter. I suggest adding 4. Discussion of the data set” and then include 3.6 and 3.7 there. In addition, my question is, how does your data set relate to the soil pedon carbon and nitrogen data for Alaska by Michaelson et al. (2013). Maybe you can refer to that during the discussion and indicate how your data set adds or fits within this data set. Also, in a discussion chapter you could state again why your data set is so value. *The headings were changed as suggested. In addition, you ask how our data compares to Michaelson et al, 2013. This paper, as well as Ping et al, 2010, are now brought up in the Introduction (lines 66-69) as well as we now discuss how our data compare to Michaelson (2013) and Ping (2010) in section 4.1:*

> Our data are the first of its kind to present organic horizon data across a range of Alaskan boreal ecosystems. Other studies have examined organic soil as a separate entity from mineral soil but with certain limitations. Michaelson et al. (2013) used Alaskan USDA-NRCS soil pedon data to examine soil properties of both organic and mineral soil but present these data for the organic portion as a whole. This study shows that there is significant variation in bulk density and C and N concentration across organic horizons, and therefore, one should not disregard these horizon-based variations. In a separate study, Ping et al. (2010) separated the organics into two horizons from boreal black spruce stands (Osurface, Oe/Oa). Our study supports the

results of Ping et al., (2010), which found a decrease in C:N ratios with increasing depth. Moreover, our study provides data from a fuller suite of soil horizons and includes data from bogs, fens, and deciduous forests.

Line 238/297 & 312: I wonder whether the accuracy of the bulk density measurements could be a reason for the differences, too. Often it is difficult to accurately measure bulk density, therefore I could think that maybe the accuracy of the bulk density measurements in both, the reference and your data set might be a reason for the differences. *Yes, bulk density measurements are hard to get. This idea is now acknowleged in both paragraphs of section 4.2: "In addition, accurate bulk density measurements is time consuming to do correctly (Nalder and Wein, 1998) and could also play a role." And "Thus, bulk density measurements play a role in these differences."*

Line 239/299: I do not understand the first sentence. What do you mean with "previous results"? Please, also consider restructuring this sentence. *This wording is now changed to be clearer and reads "To determine if the above findings…".*

Lines 246, 261, 264, 265, 274, and 282: Please insert a "the" between "than" and "measured"; Please insert a "the" between "into" and "mineral"; Please add Boreal in this sentence; I suggest writing "drained sites" instead of "drainages"; Please change "is" to "are"; I suggest writing "lack input data for" instead of "do not do a good job". *Wording changed.*

Line 264/330: I suggest moving the first sentence of this paragraph to the conclusions. *This paragraph has been rewritten.*

Figure 1: I suggest writing "included" instead of "used" in the figure caption. I suggest to improve the map because the scale bar is hardly visible and the map looks a bit blurred in general. Maybe add more names in the maps for the regions or locations where the sites are. *Region names and additional city added to the figure. Scale text enlarged and made white to improve readability. Resolution of image made the maximum size possible. Figure caption modified accordingly.*

Figure 2. I like this figure. However, I suggest to add photographs with a higher resolution. *The size and resolution of the photographs have been increased. In addition, if helpful, we can provide the original photographs to the journal.*

Figure 3. This figure shows that humic soils are most important in C and N storage. Maybe you can mention this in the text as well. *The role of lower organic horizons in C storage is now called out in section 3.2: "Therefore, even though the deeper organic horizons (M and H) have slightly lower C concentrations than the shallow horizons, their high bulk densities result in large amounts of C at depth. In fact, given average thickness, bulk density, and % C (Table 2), approximately 75% of the soil C is stored in the mesic and humic soil horizons."*

Table 1 & 2 (now Table 2 & 3) plus Table S2-S5: I have some troubles understanding the tables and whether it is significant different or not. There are a lot of superscript letters, sometimes the same, sometimes two or three. While I acknowledge the effort in putting everything into one table, I would suggest to make a separate cross-table for the p values and whether it is significant different or not. The same for the tables S2-S5 in the supplementary material. *The formatting of these tables has been redone to help make comparison of the superscript letters easier.*

Thank you for publishing this very valuable data set. *Thank you for your suggestions on how to make this manuscript better.*

Generalized_models_for_C&N_Alaska.csv: You write in the methods section that four different methods were used in collecting the soil cores. I suggest adding a column to the data set indicating which method was used for the collection of the samples. *This information is now a part of the dataset (see Table 5).*

Site_GPS_coordinates.csv: Could you add the key for the abbreviations of the regions and sites. I could not find it in the metadata what e.g. HCCS or BZ means. Also, it would be nice if the sites could be found in Figure 1, e.g. by adding the region names to the map. *This information is now added to the file (see Table 6) and mentioned in Figure 1.*

Response to Reviewer #2

Line 19/Figure 1: Add some more town names to Figure 1. Add footnote that several profiles were sampled at a given site. Include more visible North arrow and scale bar (in SI units rather than miles). Region names and additional city added to the figure. *This information is now included.*

Line 20/Figure 2: Picture bottom right. Legend includes two drainage classes? How have such cases, when arising, been processed in the dataset itself? *The caption for Figure 2 is now modified to make it clear that gleyed soil can be found in both very poorly and poorly drained soil. The determining factor between the two classes is the length of time of saturated soils, as mentioned in the table.*

Line 35/41: Change C/N to C and N dynamics to avoid possible confusion with C:N ratio. *Sentence rewritten*

Line 37/41-62: There is no second or third, please rephrase this paragraph. *Paragraph rephrased. Please see the revised text in response to Reviewer 1 above.*

Line 52/71: over 3000 thousand. *Text changed.*

Line 77/Table 1: Possibly present this as a table (new Table 1): code (X), name, description. *This information is now presented as Table 1.*

Line 156/195: one progresses. *Sentence rewritten*

Line 157/196: express bulk density as g cm-3. *Text changed.*

Line 187/36: Both horizon and layer are used. Are they used as synonyms or were (thicker) horizons divided into separate layers for sampling? Please clarify this. *Layers and horizons are the same thing. This is now clarified in line 36, but the text of the manuscript was changed so that horizon is consistently used throughout.*

Line 190/235: than then → (change to) than the. *Text changed.*

Line 204250: Change Thickness to Horizon thickness. *This header has been changed to "Soil horizon thickness".*

Line 222/270: I would suggest you move subsection 3.6 and 3.7 to a new Discussion section (4). This section could also include a comparison with results derived from other studies for boreal regions. *The headings were moved as suggested. In addition, we have added a comparison of our study to the two other studies we know of that discuss organic soil properties in section 4.1. (See response to Reviewer #1, line 222 above.)*

Line 274 – 278/336-343: The authors should at least indicate that the units of measurement, respectively domains for observations, for the properties under consideration in the two csv-files can be found in file Mega-AK metadata.xml. However, I would recommend this information is also summarised in an Appendix. As indicated, it would be a 'plus' for this data paper if the underpinning 'raw' profiles could also be made available as supplemental information, as they are not presented inhttps://doi.org/10.5066/P960N1F9, rather than just pointing at several open file reports (pdf's) as is now the case. *There is now a short description of the data found within the ScienceBase publication ("This publication includes both .csv data files as well as metadata. A short description of these files and the data found within them can be found in Tables 5 and 6.") as well as two Tables that list the column names, units (if applicable), and column descriptions. I would also like to clear that all raw data used in this study are within this ScienceBase publication. The reason to point the reader to the Open-File Reports is because there is additional information (such as Von Post descriptions and ^{210}Pb data) that may be of interest that are not in the ScienceBase publication.*

Figure 3: What depth interval is considered in this figure? The unit of g/cm2 is rather confusing (a typo?). *This graph is of C and N density and was incorrectly labeled. Therefore, depth or thickness is not included in the calculation. Thank you very much for spotting this labeling error. The figure caption and graph axes have been fixed.*

Table 1: Bulk density given as g/cm2, this should be g/cm3. *Units fixed.*

Tables 1-4: For legibility, and future typesetting by ESSD, it would be better to create three columns for each row (e.g. bulk density): n, mean, sd. The symbols for statistical significance would then also become more 'legible'. *The formatting has been redone for these tables to help make comparison of the superscript letters easier.*

Table 3 (now Table 4): Bulk density, should be g/cm3. *Units fixed.*

Under 'Data access' briefly describe the content of the zip file (csv and xml). Further, please provide an Appendix that describes the content of the csv files. *There are now two tables (5 & 6) describing that data available in the two .csv files.*

Site_GPS_coordinates.csv: There are 57 sites, yet the paper refers to over 289 profiles. It would be useful to know how many profiles were sampled at each site without readers having to digest this from file (Generalized_models_for_C&N_Alaska.csv). Further, the abbreviations for regions and sites should be provided, preferably in a look-up table (i.e. as a separate csv file). Please note that data in row 57 have 'shifted' to the right; this should be corrected. *We do not see a good place to put the number of cores per site in the text and feel that, if needed, this information is accessible using the data file. Region abbreviations in addition to names are now included in this file (see Table 6). Site names do not have much meaning outside of the research group, so we did not create a lookup table for this information.*

Generalized_models_for_C&N_Alaska.cvs. Specify units of measurement (depth (cm), bulk density (g/cm3), 13C etc.); explain all codes/abbreviations used in the file, as a 'look up' table (i.e. as a separate csv file). *This information is now included in Table 5. Tables 1, 5, and 6 have been added to the ScienceBase publication site as .txt files.*

Supplemental information S2: Please add units for bd table. *Units fixed.*

Additional improvements

Since our initial submittal of this manuscript we have come to realize that the original test used to determine differences among drainage types or age class, *difflsmeans*, does not correct for multiple comparisons. Therefore, we redid our analyses using estimated marginal means (*emmeans*; line 185), which does this correction, the result of which made some of significant differences originally presented in Tables 2-3 and Tables S2-S5 no longer significant. This change did not alter our conclusions in any way.

To aid those interested in better understanding the predicted versus measured relationships discussed in section 4.2 we have added graphs showing those results to the Supplemental Information as Figures S1 and S2.

We have added a paragraph (line 318) suggesting that, due to the inherent variability of thickness measurements, that we recommend that researchers continue to measure thickness at their sites and only use our bulk density and concentration data. This combination minimizes errors while allowing researchers, if needed, to bypass soil sampling and processing, both of which are quite labor intensive, and, thus, not always possible. The new text is below:

> One of the important uses of this dataset is the potential for estimating C and N stocks based on simple field characterizations of organic soil horizons of North American boreal forests and wetlands. Because soil sampling and processing is quite time intensive, researchers may decide to measure thicknesses of the various soil horizons within their sites, using the descriptors in Table 1, and then calculate C and N stocks using the average values presented in Tables 2, S2, S3, or S4. This approach minimizes errors associated with the high variability found for horizon thicknesses, due to variable site histories.

Generalized models to estimate carbon and nitrogen stocks of organic soil ~~layers~~horizons in Interior Alaska

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Abstract

Boreal ecosystems comprise ~~about~~ one tenth of the world's land surface and contain over 20 % of the global soil carbon (C) stocks. Boreal soils are unique in that ~~the~~its mineral soil is covered by what can be quite thick layers of organic soil. These organic soil layers, or horizons, can differ in their state of decomposition, source vegetation, and disturbance history. These differences result in varying soil properties (bulk density, C ~~content~~concentration, and nitrogen (N) ~~content~~concentration) among soil horizons. Here we summarize these soil properties, as represented by over 3000 samples from Interior Alaska, and examine how soil drainage and stand age affect these attributes. The summary values presented here can be used to gap-fill large datasets when important soil properties were not measured, provide data to initialize process-based models, and validate model results. These data are available at ~~https://doi.org/10.5066/P960N1F9~~https://doi.org/10.5066/P960N1F9 ~~(Manies, 2019)~~(Manies, 2019).

1 Introduction

Boreal soils play an important role in the global carbon (C) budget and are estimated to store between 375 - 690 Pg of C ~~(Hugelius et al., 2014; Bradshaw and Warkentin, 2015; Khvorostyanov et al., 2008)~~(Hugelius et al., 2014; Bradshaw and Warkentin, 2015; Khvorostyanov et al., 2008)~~, which is over 20 % of the global soil C stock (Jackson et al., 2017). These soils are unique in that for many boreal ecosystems a large portion of this C can be found within the organic soil layer (Jorgenson et al., 2013). This organic soil layer results from the relatively high input rates, through plant matter, that result from the high summer solar radiation this region receives. In addition, C losses from the soil are low, as cool and/or freezing soil temperatures result in low rates of decomposition. The imbalance between C inputs and losses results in thick organic soils that store large amounts of C (Jorgenson et al., 2013). There is also considerable C found in the mineral soil of these systems, especially where protected by permafrost (O'Donnell et al., 2011; Jorgenson et al., 2013).~~

~~Nitrogen (N) also plays an important role in boreal ecosystems due to N limitations on plant growth. One of the main determinants of N availability is decomposition rates. Disturbances that increase~~

decomposition can also increase N availability which, in turn, increases plant growth, offsetting some of the C losses due to increased decomposition (Finger et al., 2016).

Boreal organic soils are unique when compared to soils from other regions. First, these organic soils are thick, ranging from several centimeters to several meters (Ping et al., 2006). They are also comprised of layers which vary in their degree of decomposition. These layers can also be formed from different types of vegetation. Both factors result in soil layers of varying density. The density and thickness of these organic soil layers also vary depending on the amount of time since the last disturbance (Deluca and Boisvenue, 2012). In addition, C and N concentrations vary between layers, again depending on the degree of decomposition, source vegetation, and disturbance history.

The main disturbances of the boreal region that affect both C/N dynamics and physical soil properties are fire and permafrost thaw. Fire affects boreal soils in several ways (Harden et al., 2000). First, some portion of the organic soil is combusted during the fire, the amount of which varies depending on fire severity (Turetsky et al., 2011). Loss of insulating organic soil and the resulting darkened soil surface warms these soils post-fire, increasing decomposition rates (Genet et al., 2013). Fire severity also influences post-fire vegetation, which in turn affects the amount and chemistry of C and N inputs to the soil (Johnstone et al., 2010; Johnstone et al., 2008). Permafrost thaw, including thermokarst as well as gradual active-layer deepening, influences temperature and moisture regimes. With landscape subsidence and inundation, thermokarst wetlands occur (Schuur et al., 2015). These wetlands differ from the forested permafrost plateaus in both C and N inputs, due to differences in vegetation, and loss, due to differences in soil temperatures (Osterkamp et al., 2009), which in turn affects rates of decomposition. , which is over 20 % of the global soil C stock (Jackson et al., 2017). A large portion of this C can be found within the organic soil layer (Jorgenson et al., 2013). Although plant inputs into the soil can be relatively high during the summer, C losses from the soil are low, as cool and/or freezing soil temperatures result in low rates of decomposition. The imbalance between C inputs and losses results in organic soils that can be quite thick and store large amounts of C (Jorgenson et al., 2013). There is also considerable C found in the mineral soil of these systems, especially where protected by permafrost (O'Donnell et al., 2011). Thus, both organic and mineral soil play an important role determining the amount of C stored in boreal ecosystems.

Nitrogen (N) also plays an important role in boreal ecosystems due to N limitations on plant growth (Herndon et al., 2020). N inputs to boreal ecosystems often begin with N fixation from cyanobacteria, usually associated with mosses, or symbiotic actinomycetes, mainly the genus *Frankia*. Net N mineralization increases over the course of upland succession, until the oldest state, black spruce (*Picea mariana*) forest, when rates drop sharply (Kielland et al., 2006). Boreal ecosystems can have N restricted by certain species, such as *Sphagnum* spp., through competitive interactions and slow rates of turnover (Malmer et al., 2003). In addition, N cycling can become limited due to environmental factors such as permafrost or anerobic conditions (Limpens et al., 2006; Bonan, 1990). Once released, N availability impacts decomposition and plant growth and, therefore, can also influence rates of C accumulation and loss.

Boreal organic soils are unique when compared to soils from other regions. These organic soils can be thick, ranging from several centimeters to several meters (Ping et al., 2006). They are also comprised of layers, or horizons, which as they deepen and increase in age also increase in their degree of decomposition. These organic soil horizons are also influenced by the vegetation from which they formed (Deluca and Boisvenue, 2012). Vegetative history is usually determined by post-disturbance plant succession. Age and vegetative history not only affect the soil density, but also C and N concentrations, resulting in large differences in C and N storage among horizons.

The main disturbances that affect boreal soil properties are fire and permafrost thaw. Fires affect boreal soils through the combustion of litter and surface organic layers (as ground fuel; Harden et al., 2000), with the amount and depth of combustion regulated by fire severity (Turetsky et al., 2011). Fire directly effects surface organic soils, both in elemental composition and structure (Neff et al., 2005). In addition, there are indirect effects of fire on soil properties. The loss of insulating organic soil results in a darkened soil surface, which in turn warms post-fire soils, increasing decomposition rates from the surface downward (Mu et al., 2016; Schadel et al., 2016)(Genet et al., 2013; O'Neill et al., 2002). Gradual active layer deepening also results in enhanced soil temperatures and rates of decomposition.

Boreal organic . In addition, both fire return interval and fire severity influence post-fire vegetation and the re-accumulation of organic soil layers. As different tree and understory species have different amounts of C and N in their tissues (Van Cleve et al., 1983), changes in post-fire vegetation affect soil C and N accumulation rates and thus, the concentration of these elements in surface soil. Permafrost thaw also affects soil properties in several ways. By definition, thaw exposes older, previously sequestered C to warmer soil temperatures (Osterkamp et al., 2009), increasing rates of decomposition (Mu et al., 2016; Schadel et al., 2016). In well drained sites post-thaw conditions usually result in water draining from the soil, resulting in oxic conditions (Estop-Aragonés et al., 2018). In lowlands, permafrost thaw often results in subsidence and inundation, changing the ecosystem from a forested permafrost plateau to a thermokarst wetland (Schuur et al., 2015). Fire can often be a trigger for this rapid permafrost thaw (Myers-Smith et al., 2008). Post fire vegetation changes affects both C and N inputs, again affecting the concentration of these elements within surface organic soil layers. As both fire frequency and permafrost thaw are expected to increase in the future (Hinzman et al., 2005), biogeochemical models have a need to characterize how these disturbances will impact C and N stocks. To accurately represent future scenarios, models need to include the distinct properties of organic soil horizons found in the boreal region (Flato et al., 2013).

Despite the need to accurately portray the state and dynamic nature of boreal organic soil properties, these soils have not been adequatelywidely characterized. nor compiled into a common framework. Instead, much of the work regarding theseboreal soils has focused on predicting C and N stocks for combined organic and mineral soil horizons to a predetermined depth (Johnson et al., 2011(Johnson et al., 2011; Bauer et al., 2006). TherePing (2010) examined organic soils for Alaska, but only focused on black spruce (*Picea mariana*) forests. In addition, Michaelson et al. (2013) compiled a great deal of Alaskan-based soil data, although they present these data for the organic soil layer as a whole. Therefore, there is currently no source of summarized data of ~~these important~~ soil properties by organic soil ~~layer~~horizon. To fill this gap, we summarized ~~different~~ soil properties from a ~~large~~ database ~~(>~~of over 3000 observations~~) of observations~~ from Interior Alaska (Figure 1). ~~These~~Soil properties were ~~examined~~categorized by degree of decomposition (via classification into distinct organic soil horizons), soil drainage, and stand age. ~~Our results~~This data set can be used ~~to: 1) gap fill when an important soil property was not measured, 2) serve as baseline values to initialize boreal soil models, and 3) validate~~in many ways including field comparisons, models construction, and model ~~results.~~validation.

2 Methods

2.1 Field ~~methodology~~site classifications

~~Soil cores were taken using one or more of four different methods. The first method, most often used with surface layers, involved cutting soil blocks to a known volume. Another method often used to sample these soils uses a coring device inserted into a hand drill (4.8 cm diameter; Nalder and Wein, 1998). Wetter sites were sometimes sampled while frozen using a Snow, Ice, and Permafrost Research Establishment (SIPRE) corer (7.6-cm diameter; Rand and Mellor, 1985). Alternatively, if wetter sites were sampled unfrozen we used a 'frozen finger'. This coring method uses a thin-walled, hollow tube (~6.5 cm diameter), sealed at one end, which is inserted into the ground until it hits mineral soil. A slurry of dry ice and alcohol is then poured into the corer, freezing the unfrozen material surrounding the corer to the outside. The corer is removed and the exterior of the core is scraped to remove any large roots or material that stuck to the sample during removal. For some~~Soil cores~~, two coring methods~~ were ~~combined to create continuous samples from the surface to the mineral soil.~~

~~Cores were subdivided into subsections representing soil horizons based on visual factors such as level of decomposition, color, and root abundance. These horizon samples provided the basis for our analyses and are based on Canadian (Soil Classification Working Group, 1998) and U.S. Department of Agriculture's Natural Resource Conservation Service (Staff, 1998) soil survey techniques. A description of the horizons and the codes we used to represent them are:~~

Live moss (L)	Live moss, which is usually green. This layer generally also contains a small amount of plant litter.
Dead moss (D)	Moss that is dead and either undecomposed or slightly decomposed. This horizon would be considered an O_i horizon in the U.S. soil system.
Fibric (F)	Fibrous plant material that varies in the degree of decomposition (somewhat intact to very small plant pieces), but there is no amorphous organic material present. Very fine roots often make up a large fraction of this horizon. This horizon would be considered an O_i horizon in the U.S. soil system.
Mesic (M)	This horizon is comprised of moderately decomposed material, with few, if any, recognizable plant parts other than roots. There is amorphous present within this layer to varying degrees, but it is not smeary. This horizon is generally considered an O_e horizon (U.S. soil system).
Humic (H)	This organic horizon is highly decomposed. The soil in this horizon smears when rubbed and contains little to no recognizable plant parts. The H horizon is generally considered an O_a horizon (U.S. soil system).
Mineral (Min)	Classified as an A, B, or C mineral soil (U.S. soil system), it contains less than 20-volume-percent organic matter, as judged in the field.

Because modeling so manysampled at 58 different organic layers is difficult, we also combined layers as done in Yi et al. (2009). The fibrous horizon combined the dead moss (D) and fibric (F) horizon, while the amorphous horizon combined the mesic (M) and humic (H) horizon. These combinations were based on similarities in decomposition state and depth. We also present data forsites located within several areas of Interior Alaska (Figure 1). Several different ecosystem types of horizons that are only found at a subset of sites: ash and burned organics are only found on the surface of recently burned sites, while lichen and litter layers are only found on the surface of ~were sampled, including black spruce forests (~50%), wetlands (~26%), and deciduous and mixed forests (~16 % of%). Between 1 and 14 soil profiles. Our field studies also found several horizon types (buried wood, grass, etc.) were sampled at each site, for which we did not have enough observations (5 or less).

a total of 292 soil profiles. Sampling took place over a 15-year period from 2000-2015. We examined the effect of fire or permafrost thaw disturbance on soil properties by categorizing each of the soil profiles in relation to time since the last disturbance, which we divided into three age classes: new (<5 yrs old), young (5 – 50 yrs old), and mature (> 50 yrs old). All ‘new’new sites hadwere recently burned and thus had lost some portion of their surface organic layers (Harden et al., 2000), which in turn effects soil moisture

~~and temperature (O'Donnell et al., 2010). Young sites had recently~~ horizons (Harden et al., 2000), while young sites experienced either fire or permafrost thaw. ~~Both fire and thaw change the dominant vegetation, thus influencing C inputs into the soil. They also influence soil temperature and moisture, which in turn affects soil C stocks.~~

In addition, sites were classified according to their soil drainage. Although classifications of soil drainage have been established for many soil types ~~(Staff, 1993), the presence of permafrost necessitates modifications of this system (Survey, 1982).~~(Soil Survey Division Staff, 1993), the presence of permafrost, and its effect on drainage and soil moisture, necessitates modifications of this system (Expert Committee on Soil Survey, 1982). Although generally described ~~(Harden et al., 2003; Johnstone et al., 2008)~~(Harden et al., 2003; Johnstone et al., 2008), a soil drainage classification for permafrost landscapes is lacking. Here we present ~~such~~ a soil drainage classification decision tree, developed over the past two decades, for areas of discontinuous permafrost (Figure 2). Well drained sites are similar to traditional drainage classifications, in that water moves through the soil rapidly. However, moderately well drained drainage sites have permafrost between 75 – 150 cm, which increases soil moisture of surface organics. Somewhat poorly, poorly, and very poorly drained sites have some factor (permafrost, soil texture, or landscape position) that inhibits drainage and causes ~~redoximorephic~~redoximorphic features such as blue-grey colors in the mineral soil to appear. Somewhat poorly drained sites have a shallow active layer (often around 50 cm), which affects soil moisture and surface vegetation. Poorly drained sites experience saturated surface conditions only while seasonal ice is present (usually May through early July~~). In contrast, very poorly drained sites have saturated surface soils during the entire growing season. When sites are located on a slope >5 %, which helps promote drainage (Woo, 1986; Carey and Woo, 1999), drainage class is increased by one step; we call this the hillslope modifier. In addition, because burning increases active layer thickness, recently burned sites may have deeper or no permafrost; therefore, we ascribed their soil drainage using nearby unburned sites.~~), while very poorly drained sites have saturated surface soils during the entire growing season.

~~**2.2 Laboratory methodology**~~

~~We air-dried soils at room temperature (20 °C to 30 °C) to constant mass, then oven-dried the samples for 24-48 hours in a forced-draft oven. Organic soils~~Modification of the drainage class occurs when sites are on a slope. When sites are located on a slope of greater than 5 %, drainage increases (Woo, 1986; Carey and Woo, 1999), and therefore drainage class designation (Figure 2) is increased by one step. This is called the hillslope modifier. In addition, because burning increases active layer thickness (Gibson et al., 2018), recently burned sites may have deeper permafrost or no permafrost at all. Because the effects of these drier soil properties may not have yet propagated through factors such as thickness of the deeper organic layers, for many analyses, including this paper, it makes more sense to ascribe their soil drainage using nearby unburned sites.

2.2 Soil sampling methodology

Soil cores were obtained using several different methods. The first method, most often used with surface horizons, involved cutting soil blocks to a known volume. Another method often used inovlves a coring device inserted into a hand drill (4.8 cm diameter; Nalder and Wein, 1998). Wetter sites were sometimes sampled while frozen using a Snow, Ice, and Permafrost Research Establishment (SIPRE) corer (7.6-cm diameter; Rand and Mellor, 1985). Alternatively, if wetter sites were sampled unfrozen we used a ‘frozen finger’. This coring method uses a thin-walled, hollow tube (~6.5 cm diameter), sealed at one end, which is inserted into the ground until it hits mineral soil. A slurry of dry ice and alcohol is then poured into the corer, freezing the unfrozen material surrounding the corer to the outside. The corer is removed and the exterior of the core is scraped to remove any large roots or material that stuck to the sample during removal. Another method occasionally used in unfrozen saturated soils involves the insertion and careful removal of PVC tubing sharpened on one end. Finally, a variety of commercially- or home-made soil corers were used to obtain volumetric samples for ~6% of these data, usually for mineral soil samples. For some soil profiles, two coring methods were combined to create continuous samples from the surface to the mineral soil. While most cores were sampled into the mineral soil, some cores ended at or before the organic/mineral interface due to the presence of permafrost without proper sampling equipment or because the cores were collected for the purpose of only studying surface organics. All sampling methods were volumetric, providing the basis for bulk density calculations (g/cm^3)

Organic soil layers or horizons were described and then subdivided according to field-based visual and tactical factors such as level of decomposition, color, and root abundance, regardless of region or soil drainage. These horizons provided the basis for our analyses and are based on Canadian (Soil Classification Working Group, 1998) and U.S. Department of Agriculture's Natural Resource Conservation Service (Soil Survey Staff, 1998) soil survey techniques. A description of the horizons and the codes we used to represent them are found in Table 1, but in summary there are six main horizons: live moss (L), dead moss (D), fibric (mostly undecomposed; F), mesic (more decomposed; M), humic (very decomposed; H), and mineral soil (Min).

To aid researchers who may need to have these properties summarized in a more simplified scheme (as in Yi et al., 2009; O'Donnell et al., 2009), we also combined horizons post-hoc into a simplified scheme. Here, the fibrous horizon consists of both the dead moss (D) and fibric (F) horizons, while the amorphous horizon combined the mesic (M) and humic (H) horizons. These combinations were based on similarities in decomposition state and depth within the organic soil profile. We also present data for several types of surface horizons that are only found a small fraction of sites; those data are presented separately. Ash and burned organic surface horizons are only found in recently burned sites. Lichen and litter dominated horizons are only found on the surface of ~16 % of profiles and related to well drained forest conditions. Our field studies also found several horizon types (buried wood, grass, etc.) for which we had few observations (5 or less), and, thus, were not included in our analyses.

2.3 Laboratory methodology

Once returned from the field soils horizon samples were weighed and air-dried at room temperature (20 °C to 30 °C) to a constant mass, then oven-dried for 24-48 hours in a forced-draft oven. Organic soils (live moss, dead moss, fibric, mesic, and humic horizons) were oven-dried at 65 °C to avoid the alteration of organic matter chemistry. Mineral soils were oven-dried at 105 °C. ~~Samples were then processed in one of two ways, depending on the horizon code.~~ Mineral soil samples were gently crushed using a mortar and pestle, with care to break only aggregates, and then sieved through a 2-mm screen. Soil particles that did not pass through the screen were removed, weighed, and saved separately; soil that passed through the screen was then ground by using a mortar and pestle to pass through a 60-mesh (0.246-mm) screen. The ground material was mixed and placed in a labeled glass sample bottle for subsequent analyses. Organic soil samples were weighed, and roots wider than 1 cm in diameter were removed, weighed, and saved separately. The remaining sample material was then milled in an Udy Corp. Cyclone Sample Mill to pass through a 0.25-mm screen and placed in a labeled glass vial.

We analyzed soil samples for total C and N using a Carlo Erba NA1500 elemental analyzer (Fisons Instruments). ~~In summary, samples~~Samples were combusted in the presence of excess oxygen. The resulting sample gases were carried by a continuous flow of helium through an oxidation furnace, followed by a reduction furnace, to yield CO_2, N_2, and water vapor. Water was removed by a chemical trap and CO_2 and N_2 were chromatographically separated before the quantification of C and N (Pella, 1990a,b). ~~For organic horizon~~We assumed that mineral soil samples~~, where~~ below pH 7, which are common to Interior AK, had no inorganic carbon (IC) ~~is largely absent,~~present, and thus total C represents total organic C. For mineral-soil horizons were IC was present, we removed carbonates using the acid fumigation technique ~~(Komada et al., 2008) prior to running samples. Briefly, we preweighed samples in silver capsules and transferred them to a small~~(Komada et al., 2008) prior to running samples. To do this, we preweighed samples in silver capsules and transferred them to a desiccator. Samples were wetted with 50 µL of deionized water and then exposed to vaporous hydrochloric acid (1 N) for a minimum of 6 hours, during which carbonates degassed from samples as carbon dioxide.

2.~~3~~4 Data quality and statistical methodology

Often the soil descriptions at the interface of the organic and mineral soil included notations indicating that these horizons consisted of mixed organics and mineral soil. ~~In~~Using visual and textural cues the field~~ the best call was made to if it was~~, horizons were categorized as either mineral (< 20 % C) or organic (≥ 20 % C). However, chemistry data ~~often~~sometimes shows these horizons were ~~mislabeled~~miscategorized due to slight under or over estimations of OM content (for example, a mineral soil with 22 % C). We used C chemistry to remove organic soils with < 20 % C from our analyses.

All statistical analyses were run using the R program ~~(Team, 2017)~~(R Core Team, 2017). ~~We first checked the data for~~ Data were transformed to meet assumptions of normality~~. Much of the data needed transformation~~ (Table S1). The effects of drainage and age class~~,~~ for all soil horizons with the exception of the fibrous and amorphous horizons, was tested for significant difference among the different soil horizons using the mixed-effects model command *lmer* ~~(lme4; Bates et al., 2015)~~(lme4; Bates et al., 2015), using soil profile (or soil core) as the random effect. When significant, differences among drainage types or age class were determined using ~~the *difflsmeans* command (lmerTest; Kuznetsova et al., 2017), which produces a Differences of~~ estimated marginal means (Least~~ Squares Means table with p-values. For the evaluation of drainage and age class on thickness~~-squares means; *emmeans*) (Lenth et al., 2020). No interactions were examined. Evaluation for the fibrous and amorphous horizons, because all ~~applicable~~ samples were within a single soil profile~~ were combined, we used an~~, was done using the analysis of variance model (*aov*) with the Tukey honestly significant difference (*TukeyHSD*) function.

3. Dataset Review

3.1 Bulk density

Bulk density varied by depth and was significantly different ($p < 0.05$) among all horizon types (live moss, dead moss, fibric, mesic, humic, and mineral soil; Table 1~~), including the two combined horizon codes (fibrous and amorphous).~~). Surprisingly, as they are comprised of very similar material, even the live and dead moss ~~layers~~horizons had significantly different bulk densities. Bulk density increases ~10-fold from one ~~layer~~organic horizon to the next ~~as one progress~~ down the soil profile (from 0.~~021~~022 g~~/cm^3~~ cm^{-3} for live moss to 0.215 g~~/cm^3~~ cm^{-3} for ~~humics~~the humic horizon). These differences are likely related to the length of time each soil ~~layer~~horizon has had to decompose. As soil

~~layers~~horizons become older, plant fibers break down physically and biologically, becoming smaller and more ~~compressible~~compressed.

Bulk density also varied by drainage class~~: well~~, particularly at the deeper depths. Well drained sites tended to have higher bulk densities than other poorer soil drainage classes~~ (Table S1). While this pattern was not always significant it was consistent~~, especially for ~~all horizons except for the dead moss horizon, where it was the~~ ~~2^{nd}~~ ~~highest. The higher~~the deeper soil horizons (e.g. fibric and mesic; Table S2). Higher bulk densities ~~of well-drained sites are~~with better drainage is likely related to two factors: 1) the influence of lichens and ~~litters~~litter, which ~~are more~~ often found ~~within~~at well drained sites, and have higher bulk densities than moss (Table ~~3~~4), and 2) the influence of mineral soil, which, due to shallower organic soils, is more likely to be incorporated into fibric (F) and mesic (M) horizons. ~~This last reason~~Greater mineral incorporation into organic layers of shallow well drained soils is supported by the lower % C values also found within well-drained F and M horizons (Table ~~S2~~S3). New (< 5 yr old) sites ~~tended to have slightly~~often had higher bulk densities than the ~~young and mature~~older age classes (~~all horizons except for the humic horizon;~~ Table ~~S1). However, the~~S2). There were, however, very few significant differences ~~weren't usually significant~~in bulk density by age class, so this factor does not appear to play strong role in determining bulk density.

3.2 Carbon

Upper, shallow organic soil ~~layers~~horizons (live moss, dead moss, and fibric horizons) differ from deeper horizons (mesic and humic horizons) in several respects. Shallow horizons are consistently higher in % C than deeper horizons (Table 2). However, upper, shallow horizons are lower ~~layers (mesic, humic, and mineral horizons; Table 1). Bulk~~in bulk density ~~values also increase with depth for these~~than deeper horizons~~,~~ (Table 2), so that C ~~storage~~density values (g cm^{-3}) increase dramatically with depth (Figure 3).

~~C content varied by drainage class for~~ Therefore, even though the ~~fibric~~deeper organic horizons (M and ~~mesic layers (Table S3), which had~~ H) have slightly lower ~~%~~C concentrations than the shallow horizons, their high bulk densities result in large amounts of C ~~values in~~at depth. In fact, given average thickness, bulk density, and % C (Table 2), approximately 75% of the soil C is stored in the mesic and humic soil horizons.

There were few clear trends with C concentration with drainage class, although moderately well drained ~~as compared to more~~sites usually had higher C concentrations than the other drainage classes, especially somewhat poorly drained sites~~.~~ (Table S3). Lower C values for the fibric and mesic well-drained sites are likely due to the inclusion of mineral soil material into these horizons~~,~~. While this difference is likely due in large part to natural process such as cryoturbation or aeolian contributions~~. Somewhat poorly drained sites also have lower C values for all organic soil~~ , these horizons ~~as compared to other non-~~are thinner in well drained ~~classes~~sites (Table 3), so any accidental inclusion of mineral soil within these horizons during sampling would have more of an effect.

C ~~content~~concentration increased with increasing age class for ~~the fibric and mesic~~all organic horizons but the humic horizon (Table ~~S2~~S3). Since all sites classified as 'new' were recently disturbed by fire, this increase could be due to ~~both~~ the inclusion of more live roots and/or the loss of ash~~, which~~ in older stands. Ash has a lower C content (Table 4) and is a component of recently burned soil's surface ~~layers, within these two~~ horizons ~~as stands recover~~.

3.3 Nitrogen

~~All horizons had significantly different N concentrations from each other (Table 1). The amount of N within the organic layers increased with depth. N was 2-3 times higher in the organic horizons as compared to mineral soil. There was significant variability in N by drainage class for each horizon type (Table S3). The poorly and very poorly drained sites had greater concentrations of N than then other drainage classes for the fibric (F), mesic (M), and humic (H) horizons. These higher concentrations may be due to the number of these observations (~40 %) from bogs and fens, which have been shown to have higher litterfall N concentrations (Finger et al., 2016). There was also a trend of higher N in the new and younger stands for the live and dead moss horizons (Table S3), which may be related to N quality of early succession litterfall.~~

N concentration within the organic horizons increased with depth and then declined again in the mineral soil (Table 2). There was significant variability in N by drainage class for each horizon type (Table S4). The poorly and very poorly drained sites had greater concentrations of N than other drainage classes for the fibric (F), mesic (M), and humic (H), and mineral horizons, and lower concentrations of N in the dead moss (D) horizon. These higher values are likely because N builds up under saturated conditions, due to low rates of microbial activity, limiting decomposition (Limpens et al., 2006). There was also more N in the live and dead moss horizons of the new and younger stands (Table S3). These differences are likely related to differences in N quality of early succession litterfall (Bonan, 1990).

3.4 C:N ratio

~~All horizon types had significantly different C:N ratio from one another (Table 4), with these~~ C:N ratios ~~tending to decrease as the~~ patterns followed those of C and N, with the surface organic horizons ~~deepen and become~~(live moss, dead moss, and fibrics) having more ~~decomposed. There were no trends in C:N ratio by drainage class. Age class played a role in~~similar values than the deeper soil organic horizons (Table 2). Well drained sites tended to have lower C:N ratios ~~for~~(Table S5), likely caused by the ~~less decomposed horizons, where~~lower C~~:N ratio increase as stands aged.~~ concentrations found there (see section 3.2). C:N ratio increased with age class, but only in the surface organic horizons (live moss, dead moss, and fibrics). These trends ~~are~~appear to be more influenced by ~~changes~~differences in N by age class~~,~~ than changes in C.

3.5 ~~Thickness~~Soil horizon thickness

The factor that varied the most by horizon was the thickness of each horizon type (Table ~~1).~~2), and, unlike most of the other factors, the standard deviation was often greater than the mean. There was a very strong effect of drainage on horizon thickness, with the well-drained sites having much thinner soil horizons (and no humic horizon) than the other drainage classes and the very poorly drained sites having much thicker soil horizons that the other drainage classes (Table ~~2~~3). Age class also plays a role in horizon thickness: new sites (<5 yrs old) had much thinner organic soil horizons than young or mature sites (Table 3). Since new sites recently burned, these thin soil horizons are the result of the loss of organics due to combustion. Both fire return interval and fire severity impact the amount of legacy soil remaining ~~(Harden et al., 2012)~~(Harden et al., 2012), therefore fire history likely plays a large role in horizon thickness.

Vegetation could also influence horizon thickness. An examination of these data that included current surface vegetation found greater thicknesses for sites with *Sphagnum* sp. and sedges, although this factor usually ~~wasn't~~was not statistically significant. Historical vegetation could also influence horizon thickness. For instance, if a site was *Sphagnum* dominated in the past, even if ~~it's~~it is not the current surface vegetation, the soil profile is more likely to have thicker soil ~~layers~~horizons due to the slow decomposition rate of *Sphagnum* ~~(Turetsky et al., 2008).~~(Turetsky et al., 2008). Because such historical factors are difficult to measure and predict, we recommend that ~~users~~researchers obtain their own measurements of ~~these~~organic horizon thickness whenever possible and, if using the thickness data ~~include the natural~~presented in Table 3, account for the variability ~~in~~found for thickness estimates in their analyses.

~~3.6~~4.0 Discussion of the data set

4.1 Comparison to other data sets

Our data are the first of its kind to present organic horizon data across a range of Alaskan boreal ecosystems. Other studies have examined organic soil as a separate entity from mineral soil but with certain limitations. Michaelson et al. (2013) used Alaskan USDA-NRCS soil pedon data to examine soil properties of both organic and mineral soil but present these data for the organic portion as a whole. This study shows that there is significant variation in bulk density and C and N concentration across organic horizons, and therefore, one should not disregard these horizon-based variations. In a separate study, Ping et al. (2010) separated the organics into two horizons from boreal black spruce stands ($O_{surface}$, O_e/O_a). Our study supports the results of Ping et al., (2010), which found a decrease in C:N ratios with increasing depth. Moreover, our study provides data from a fuller suite of soil horizons and includes data from bogs, fens, and deciduous forests.

4.2 How well do these values represent theother data?

To testWe tested how well the values in Table 1 – 3 estimateour data from Interior AK can predict C and N stocks we compared predicted versus measured stocks for two locations.in other studies. Our first test was for 142 samples taken from two fire chronosequences (time since fire) located near Thompson, Manitoba (Manies et al., 2006)(Manies et al., 2006). Each chronosequence represents a different drainage class: moderately well drained versus somewhat poorly drained. These data were taken usingbased on the same methods of sampling and describing soil horizons. We used the Using the horizon designations (Table 1) and horizon thickness (cm) from the Canadian data, we assigned bulk density, C, and N values based on horizon only (Table 1) and thickness based on horizon and drainage (Table 2). For those profiles with high C or These predicted horizon-based C and N stocks (> 5 gC/m^2were summed for each soil profile and > 0.01 gN/m^2, respectively) compared to the measured values. We found our predicted stocks were consistently relatively evenly distributed between being lower or higher than measured stocks. This result is mostly due to greater predicted than observed thicknesses, most dramatically for the mesic (M) horizons. In addition, our predicted bulk density values tended to be slightly higher than (Figure S1), with the majority of estimated stocks (>85%) within 50% of measured values especially for the fibric (F) and humic (H) horizons. We found that most the observations with large differences in predicted versus observed stocks had anomalouslyand over 60% within 20% of measured stocks. Soil profiles with much higher predicted than measured stocks were due to very low measured bulk densities. For example, there were some thick fibric horizons with (e.g., a measured bulk density for a fibric horizon of 0.01 g/cm^2 (versuscm^3, as compared to the predicted value of 0.06 g/cm^2)cm^3). The differences we found between measured and mesic horizons with a bulk density of 0.05 g/cm^2 (versus the predicted value of 0.15 g/cm^2). These resultspredicted stocks could be because a) our data, from Interior Alaska, does not well represent other black spruce, boreal regions, or b) our average values, especially thickness, tend to overestimate stocks.

To determine if our previous results were due to regional differences between the Alaskan and Canadian sites in factors, such as disturbance history or vegetation composition. In addition, accurate bulk density measurements is time consuming to do correctly (Nalder and Wein, 1998) and could also play a role.

To further explore the predictive capabilities of our data, we also compared predicted versus measured C stocks for a second study, this one located within Alaska ~~(Kane and Ping, 2004). They measured~~ (Kane and Ping, 2004), in which horizon thickness (all samples), % C (all samples), and bulk density (one 5.08 cm diameter sample per horizon per site) for soil profiles were measured along a continuum of tree productivity. ~~This work~~ To calculate predicted C stocks we used their thickness values with bulk density and % C values from Table. 1. However, Kane and Ping (2004) used the US Soil System to describe and sample their soils, dividing the organic ~~horizons~~soil profile into O_i and O_e/O_a horizons. We chose to represent their O_i data, which they described as slightly decomposed moss, ~~with~~using our ~~dead moss (D)~~fibrous horizon and their O_e/O_a data, which they described as intermediately decomposed moss with rare saprics, as our ~~fibric (F) horizon. For this dataset our predicted stocks were much less than measured stocks.~~amorphous horizon. Predicted C stocks were higher than measured stocks (Figure S2). This result was mostly due to differences in bulk density values between our amorphous horizon and their O_e/O_a horizon. Their study had O_e/O_a bulk density values that ranged between 0.06 and 0.12 g/cm^2, which is typical of our fibric (F) and mesic (M) horizons (Table 2). When we model their O_e/O_a data using F values, we slightly underestimate stocks, while if we model their O_e/O_a data using M values we slightly overestimate their stocks (Figure S2). Thus, bulk density measurements play a role in these differences. These results also demonstrate that soil description protocols play an important role in characterizing C and N stocks and, in this case, the different system used to identify and sample organic soil horizons may not be equivalent.

4.3 Caveats and suggestions for use

One of the important uses of this dataset is the potential for estimating C and N stocks based on simple field characterizations of organic soil horizons of North American boreal forests and wetlands. Because soil sampling and processing is quite time intensive, researchers may decide to measure thicknesses of the various soil horizons within their sites, using the descriptors in Table 1, and then calculate C and N stocks using the average values presented in Tables 2, S2, S3, or S4. This result is due to underestimatingapproach minimizes errors associated with the high variability found for horizon thicknesses (both the O_i and O_e/O_a horizons) and bulk density (O_e/O_a horizon). The discrepancy in bulk density values may be because the bulk density samples taken by Kane and Ping (2004) were 5.08 cm in diameter, while the actual thickness of these horizons they were measuring ranged between 1 and 25 cm. Therefore, their measurements likely did not accurately characterize their soil horizons. These results also point out potential issues that could arise with data described in a different manner (here the US Soil System). , due to variable site histories.

While C stocks of mineral soils were not evaluated in this study, this region contains large amounts of C within mineral soils, especially within Yedoma deposits (Hugelius et al., 2014; O'Donnell et al., 2011). The mineral soil data presented here represent mostly the uppermost mineral soil. Additional examinations into bulk density and C concentrations of Alaskan mineral soil can be found in Ping et al. we made our best guess as to which of our horizons best fit their data, the measured O_e/O_a bulk density ranged between 0.06 and 0.12 g/cm^2, implying that their samples were likely a combination of (2010), Michaelson et al. (2013), and Ebel et al. (2019).fibric (F) and mesic (M) horizons (which have average bulk densities of 0.07 and 0.15 g/cm^2, respectively, Table 1).

3.7 Caveats

It is important to include mineral soil in soil C stock evaluations, as the mineral soil of this region contains large amounts of C, especially within Yedoma deposits (Hugelius et al., 2014; O'Donnell et al., 2011). However, the mineral soil data presented here do not represent full mineral soil profiles, since our sampling often stopped 5-10 cm into mineral soil.Although our data provide an important resource for several properties of organic horizons, we acknowledge that our samples are dominated by mature sites from areas that are not well drained. Therefore, as additional soil horizon data is sampled, we encourage researchers to expand upon the work presented here.

5 Additional examinations into bulk density and C concentrations of Alaskan mineral soil can be found in Ping et al. (2010), Michaelson et al. (2013), and Ebel et al. (2019).

Our analysis includes Alaska data from >3,000 soil samples and >290 soil profiles, with samples dominated by soil profiles from somewhat poorly, poorly, and very poorly drainages. Age classes were also not equally distributed, as almost 50 % of our soil profiles were from mature stands. This unbalanced design means that our results may not adequately represent all drainages and age classes, particularly well-drained sites. Deciduous stands are not well represented. In addition, we have few sites from shrub dominated ecosystems. Our data best represents black spruce dominated forests and thermokarst wetlands in Alaska.

4 Data Access

~~All data used in this manuscript is available from https://doi.org/10.5066/P960N1F9 (2019). In addition, many additional soil attributes, such as volumetric water content, von Post decomposition index, and additional chemistry, can be found for the majority of these data through various USGS Open-File Reports (Manies et al., 2017; Manies et al., 2016; Manies et al., 2014; O'Donnell et al., 2013; O'Donnell et al., 2012; Manies et al., 2004).~~

~~**5 Conclusions**~~

~~Boreal ecosystems are especially sensitive and vulnerable due to climate change. Unfortunately, most models do not do a good job recreating high latitude biogeochemical processes (Flato et al., 2013). One reason for the discrepancies between model results and data is that many large scale models do a poor job at recreating soil thermal dynamics, which is necessary for recreating permafrost dynamics~~ All data used in this manuscript are available from https://doi.org/10.5066/P960N1F9 (2019). This publication includes both .csv data files as well as metadata. A short description of these files and the data found within them can be found in Tables 5 and 6. In addition, many additional soil attributes not included in that publication, such as von Post decomposition index and additional soil chemistry information, can be found for the majority of these data through various USGS Open-File Reports (Manies et al., 2017; Manies et al., 2016; Manies et al., 2014; O'Donnell et al., 2013; O'Donnell et al., 2012; Manies et al., 2004).

6 Conclusions

Boreal ecosystems are especially sensitive and vulnerable due to climate change. Models may not accurately forecast high latitude biogeochemical processes for many reasons (Flato et al., 2013). One reason for the discrepancies between model results and data is that many models lack the input data required, including important factors for modeling soil thermal dynamics like bulk density (Koven et al., 2013; Khvorostyanov et al., 2008). While these processes are starting to be incorporated into land surface and regional models ~~(Koven et al., 2013; Khvorostyanov et al., 2008)~~(see, for example, Genet et al., 2013; Koven et al., 2011)~~. While these processes are starting to be incorporated into land surface and regional models (see, for example, Genet et al., 2013; Koven et al., 2011), currently few models include the "distinct properties of organic soils" that are found in the boreal region (Flato et al., 2013). The data presented in this paper provide a needed dataset for initializing and validating models related to boreal organic soils. In addition, these data can be used by scientists to gap-fill in instances when an important soil property was not measured.~~

, currently few models include the distinct properties of organic soils that are found in the boreal region (Flato et al., 2013). The >3,000 soil samples, from >290 soil profiles, presented in this paper provide information regarding the important soil properties of bulk density, C concentration, N concentration, C:N ratios, and thickness by organic soil horizon. Such data are needed for initializing and validating models related to boreal organic soils. In addition, these data can be used by scientists to calculate C and N stocks where researchers only have soil horizon thickness data or to address shortcomings of missing data in instances when an important soil property was not measured.

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Author contribution

KM prepared the manuscript with the help of MW and JH. All authors were involved in supporting the collection of these data.

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Figure 1. Location of the sites used in this study, all located within Interior Alaska. Regions, as ascribed in the dataset, are noted in red. Cities are written in yellow. (Map data: Google, 20182020.)

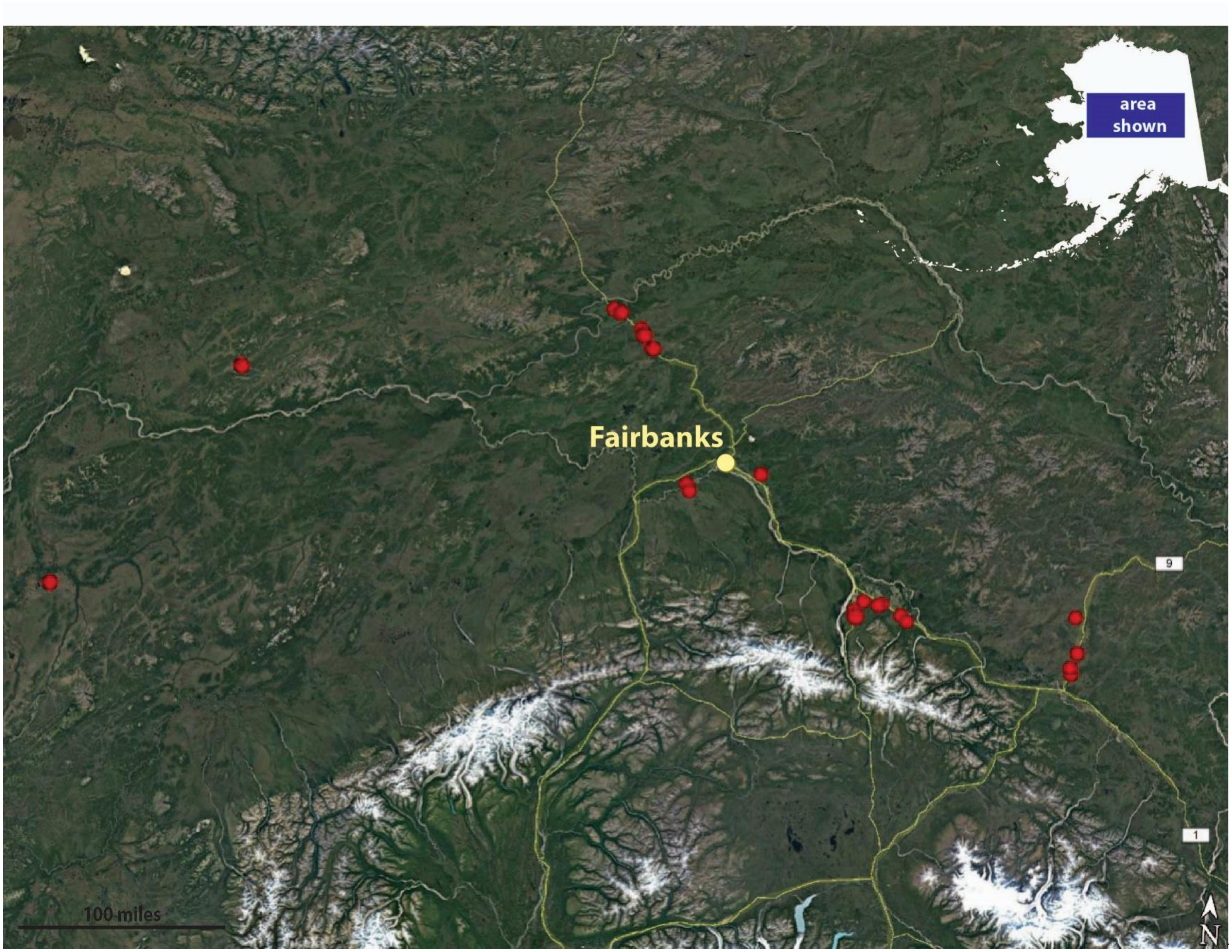

area
shown
Fairbanks
9
1
100 miles
N

Figure 2. Soil drainage class decision tree.

Decision Tree		Drainage class	Characteristics
Are there gravel or cobbles in the top 100 cm (and no permafrost)?	Yes →	Well-drained	*Little moisture in the surface* *Thin organics (<20 cm, often much less)* *Oxidized colors in mineral soil*
↓ No			
Is there permafrost between 75 - 150 cm and no persistent water table?	Yes →	Moderately well-drained	*Moderate surface moisture* *Silty mineral soil* *Blocky structure*
↓ No			
Is there permafrost above 75 cm and no persistent water table?	Yes →	Somewhat poorly drained	*Considerable surface moisture* *Clay mineral soils* *Blocky structure* *Slightly oxidized colors in mineral*
↓ No			
Is the surface (~10-30 cm) saturated but only for part of the growing season?	Yes →	Poorly drained	*When not saturated surface still moist* *Clay mineral soils* *Gleyed mineral soil* *Mottles* *Massive structure*
↓ No			
Is the surface (~0-30 cm) saturated for the entire growing season?	Yes →	Very poorly drained	*Satrurated surface* *Gleyed mineral soil*

Slope modifier:
If the slope of the site is greater than 5% the site should be better drained by one drainage class.
For example, a somewhat poorly drained site would become a moderately well drained site.

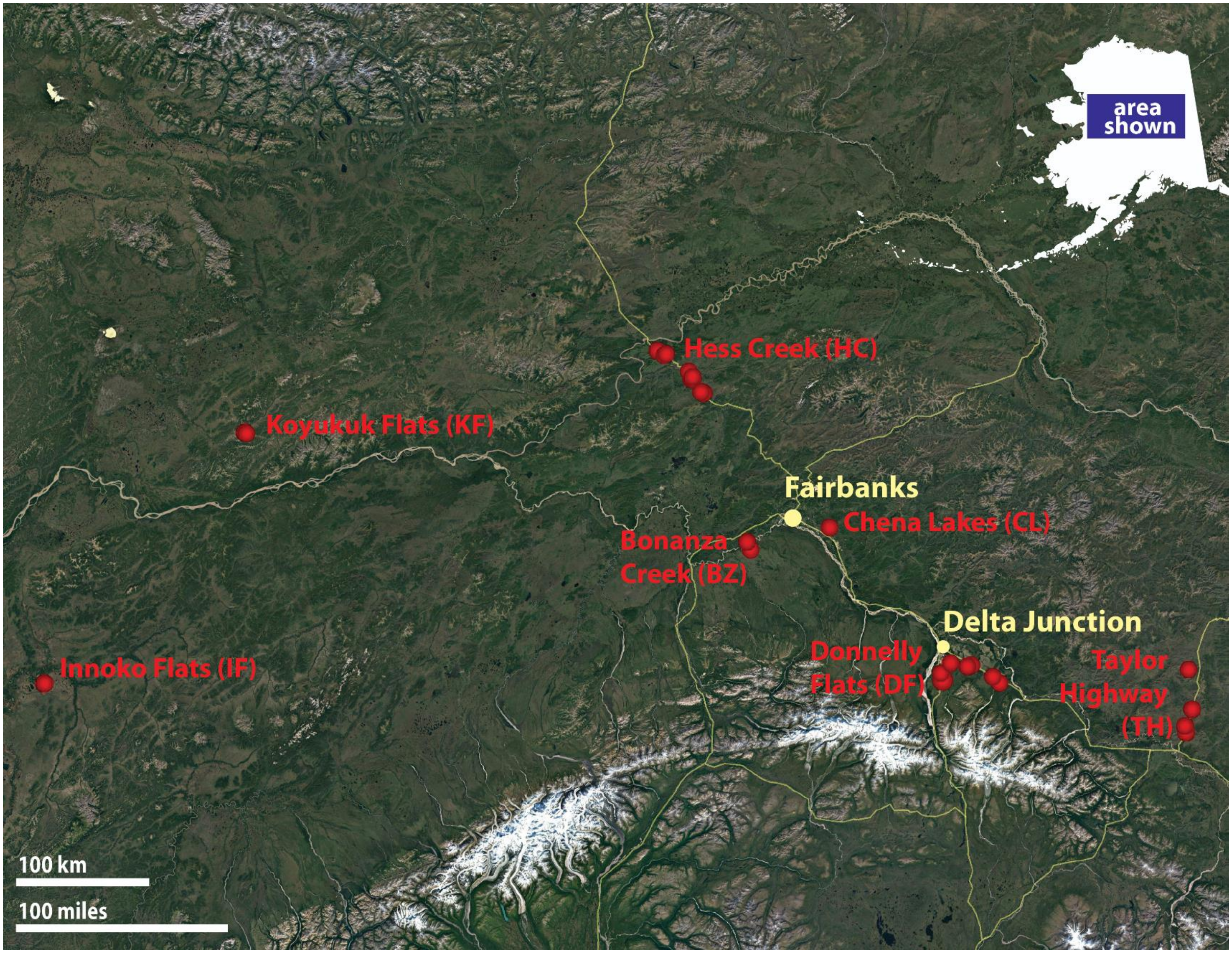

area shown
Hess Creek (HC)
Koyukuk Flats (KF)
Fairbanks
Chena Lakes (CL)
Bonanza Creek (BZ)
Delta Junction
Donnelly Flats (DF)
Taylor Highway (TH)
Innoko Flats (IF)
100 km
100 miles

Figure 2. Soil drainage class decision tree. Beginning in the top left, if the soil meets the criteria, one has found the designated drainage class, having the characteristics located on the right. If the soil of interest does not meet the criteria, one moves down to the next drainage class to determine if its criteria is met. Drainage classes are also modified by slopes of greater than 5 % by moving up one drainage class.

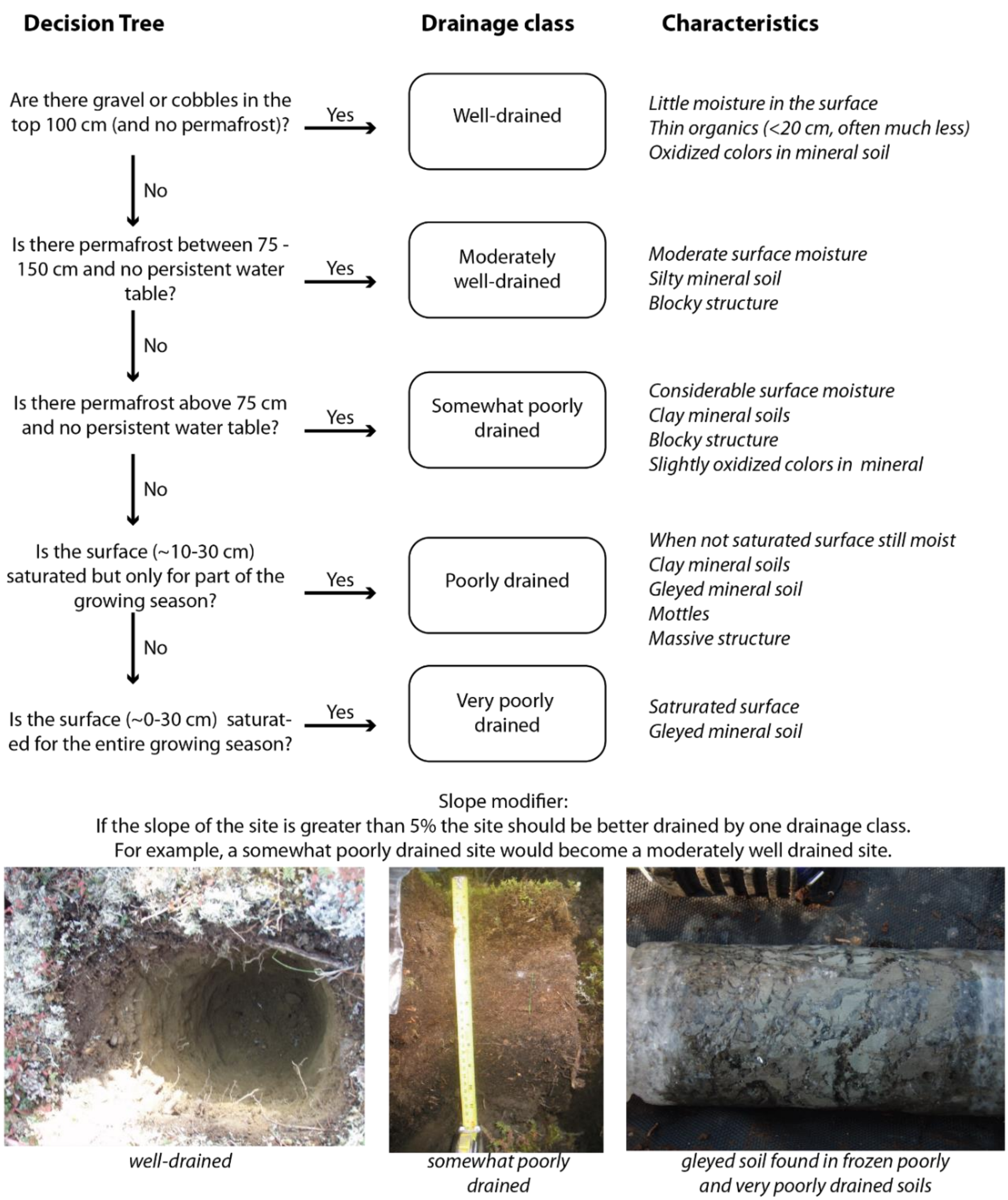
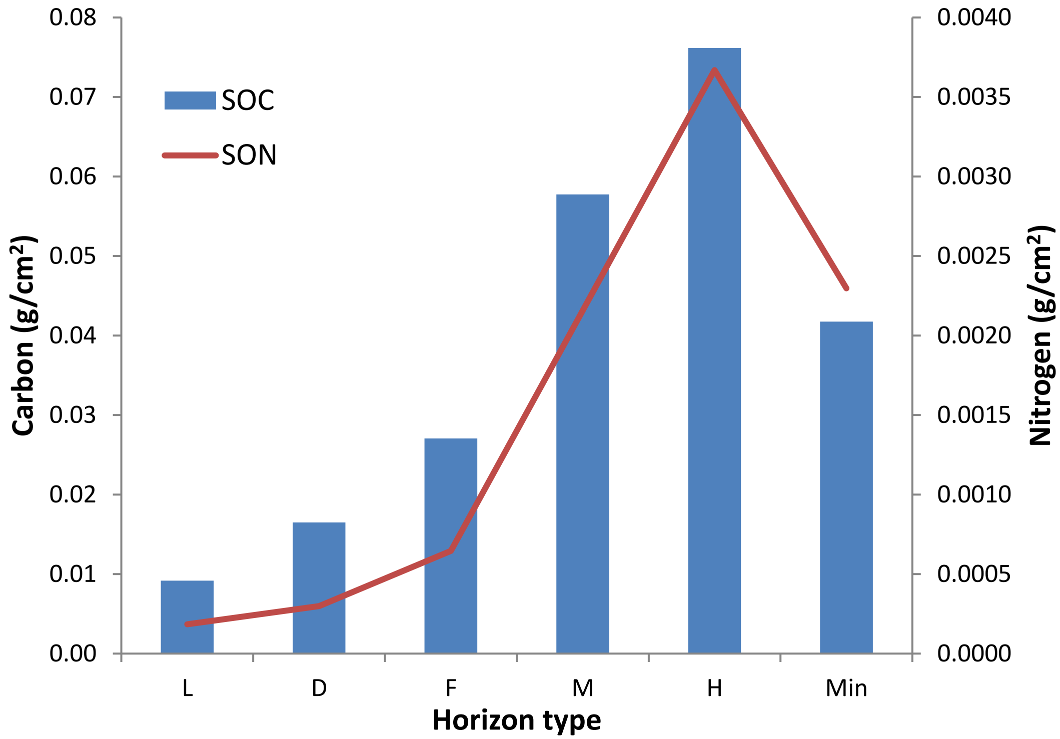
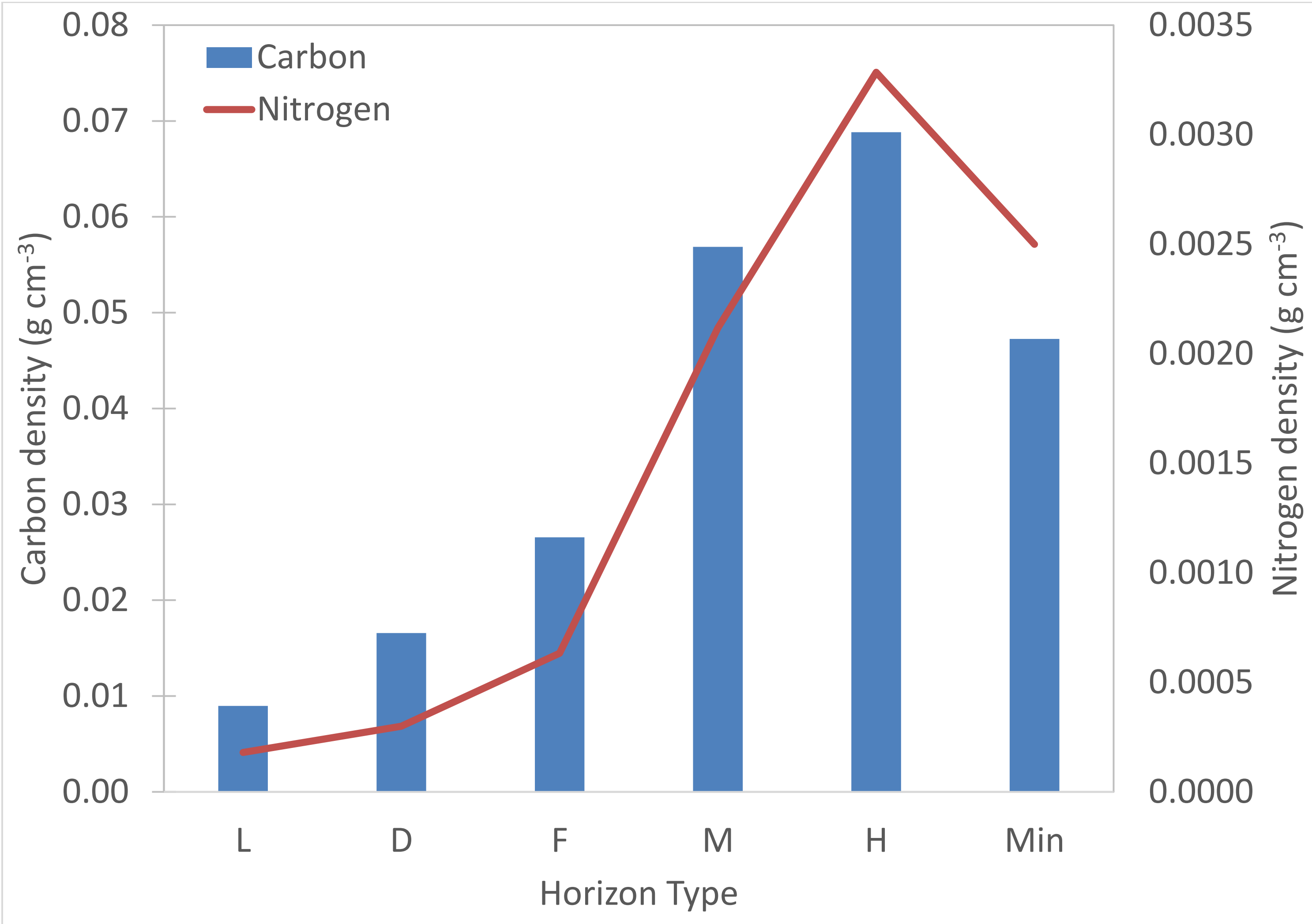


Figure 3. Trends in carbon and nitrogen ~~storage~~density (g~~/cm~~^{2} cm^{-3}) by horizon type using average values for bulk density, carbon, and nitrogen (~~see~~ Table ~~1~~2). Horizon designations: L = live moss, D = dead moss, F = fibric, M = mesic, H = humic, Min = mineral.





Carbon
Nitrogen
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Carbon density (g cm-3)
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Nitrogen density (g cm-3)
L
D
F
M
H
Min
Horizon Type

Table 1. A description of the soil horizons, as assigned by examining the composition of the soil horizon, including the degree of decomposition, color, and root abundance.

Horizon Type	**Horizon Code**	**Description**
Live moss	L	Live moss, which is usually green. This horizon generally also contains a small amount of plant litter. Plant material is completely undecomposed.
Dead moss	D	Moss that is dead and either undecomposed or slightly decomposed. Plant parts are easily identifiable. This horizon would be considered an O_i horizon in the U.S. soil system.
Fibric	F	Fibrous plant material that varies in the degree of decomposition (somewhat intact to very small plant pieces), but there is no amorphous organic material present. Very fine roots often make up a large fraction of this horizon. This horizon would be considered an O_i horizon in the U.S. soil system.
Mesic	M	This horizon is comprised of moderately decomposed material, with few, if any, recognizable plant parts other than roots. There is amorphous present within this horizon to varying degrees, but it is not smeary. This horizon is often considered an O_e horizon (U.S. soil system).
Humic	H	This organic horizon is highly decomposed and is mostly amorphous material. The soil in this horizon smears when rubbed and contains little to no recognizable plant parts. The H horizon is generally considered an O_a horizon (U.S. soil system).
Mineral	Min	Classified as an A, B, or C mineral soil (U.S. soil system), it contains less than 20-volume-percent organic matter, as judged in the field.

Table 2. Bulk density (g/~~cm^2~~cm^3), C (%), N (%), C:N ratio, and thickness (cm) for the main horizon codes~~. Values in parenthesis are standard deviations.~~ averaged across all drainage and age classes. Significant differences ($p < 0.05$) among the main six horizon codes are indicated with different letters. There are no thickness values for mineral soil because these results would reflect the thickness sampled, not the actual thickness of this horizon. Stdev is one standard deviation.

Horizon Code	**Bulk Density (g/~~cm^2~~cm^3)**			**Carbon (%)**			**Nitrogen (%)**			**C:N**		
	mean	stdev	n	mean	stdev	n	mean	stdev	n	mean	stdev	n
live moss (L)	0.022^{a} ~~(0.018) n=138~~	(0.018)	138	41.7^{a} ~~(3.8) n=145~~	(3.8)	145	0.84^{a}	~~0.84^{a}~~ (0.25) ~~n=145~~	145	53.8^{a}	~~54^{a}~~ (16) ~~n=141~~	141
dead moss (D)	0.039^{b}	~~0.039^{b}~~ (0.026) ~~n=540~~	540	42.6^{a} ~~(3.8) n=538~~	(3.8)	538	0.77^{a}	~~0.77^{b}~~ (0.27) ~~n=537~~	537	62.1^{a}	~~62^{b}~~ (23) ~~n=541~~	~~14.3^{b} (26.0) n=161~~ 541
fibric~~fibrics~~ (F)	0.065^{c}	~~0.065^{e}~~ (0.041) ~~n=552~~	552	41.0^{a} ~~(5.6) n=566~~	(5.6)	566	0.98^{a}	~~0.98^{c}~~ (0.42) ~~n=564~~	564	47.6^{a}	~~48^{c}~~ (17) ~~n=552~~	552
~~mesics~~mesic (M)	0.149^{d}	~~0.149^{d}~~ (0.077) ~~n=634~~	634	38.2^{b} ~~(6.8) n=650~~	(6.8)	650	1.42^{b}	~~1.42^{d}~~ (0.54) ~~n=651~~	651	30.6^{b}	~~31^{d}~~ (13) ~~n=634~~	634
~~humics~~humic (H)	0.215^{e}	~~0.215^{e}~~ (0.096) ~~n=160~~	160	32.1^{c}	~~32.1^{e}~~ (6.6) ~~n=164~~	164	1.53^{c}	~~1.53^{e}~~ (0.44) ~~n=164~~	164	22.2^{c}	~~22^{e}~~ (6) ~~n=160~~	160
mineral (Min)	0.731^{f}	~~0.731^{f}~~ (0.380) ~~n=584~~	584	6.5^{d} ~~(6.2) n=674~~	(6.2)	674	0.34^{d}	~~0.34^{f}~~ (0.32) ~~n=673~~	673	18.0^{d}	~~18^{f}~~ (7) ~~n=603~~	~~n/a~~603
fibrous (D~~&~~ & F)	0.052	~~0.052~~ (0.037) ~~n=1092~~	1092	41.8	~~41.8~~ (4.8) ~~n=1104~~	1104	0.88	~~0.88~~ (0.37) ~~n=1101~~	1101 ~~29 (12) n=794~~	54.6	(21)	1101
amorphous (M~~&~~ & H)	0.162	~~0.162~~ (0.085) ~~n=794~~	794	36.9	~~36.9~~ (7.2) ~~n=814~~	814	1.44	~~1.44~~ (0.52) ~~n=815~~	~~55~~ 815~~(21) n=1093~~	28.9	(12)	813

~~*p-value very close to 0.05 (thickness F vs M = 0.044). These values are so close to our threshold of 0.05 we would like to recognize that there is a chance that the bulk density values are not significantly different from each other.~~

Table ~~2~~3. Thickness (cm) of the main horizon codes by soil drainage and age class. The mineral soil horizon was not included in this table because the way in which we sampled ~~the~~ mineral soil led to arbitrary thicknesses. ~~Data presented are means, standard deviations (in parentheses), and number of observations.~~ Significant differences ($p < 0.05$) for horizon codes~~,~~ among ~~either~~ drainage ~~or age class,~~classes are indicated with different letters. Stdev is one standard deviation.

Horizon		Drainage					Age ~~class~~		
		Well~~-~~drained	Moderately ~~well-drained~~Well Drained	Somewhat ~~poorly drained~~Poorly Drained	Poorly ~~drained~~Drained	Very ~~poorly~~Poorly Drained	New	Young	Mature
live moss (L)	mean	2.~~2 (1.0) n=6~~2[a]	2.~~5 (1.1) n=13~~2 [a]	2.1 ~~(1.1) n=75~~[a]	1.5 ~~(0.7) n=18~~[a]	4.~~3 (2.1) n=26~~3[b]	~~1.0 (-) n=~~21.0[ab]	2.~~6 (2.1) n=43~~6[a]	2.~~4 (1.2) n=93~~4[b]
	stdev	(1.0)	(0.8)	(1.1)	(0.7)	(2.1)	(-)	(2.)	(1.2)
	n	6	11	75	18	26	2	42	92
dead moss (D)	mean	3.3[a] ~~(1.6) n=20~~	~~8.1[a]~~ (7.~~2)~~ ~~n=20~~4[a]	7.~~5[a] (10.7) n=78~~6[a]	6.5[a] ~~(6.5) n=21~~	38.~~8[b] (44.5) n=36~~1[b]	6.~~3[a] (4.5) n=17~~3[ab]	16.~~4[b] (19.7) n=45~~3[a]	14.~~7[b] (30.2) n=99~~1[b]
	stdev	(1.6)	(6.8)	(10.8)	(6.5)	(40.8)	(4.5)	(20.0)	(27.5)
	n	6	19	77	21	34	17	42	98
fibric (F)	mean	3.1[a]	9.6[bc]	7.9[b]	13.7[c]	40.2[d]	6.4[a]	19.8[b]	14.0[c]
~~fibrics (F)~~	stdev	~~3.1[a]~~ (3.0) ~~n=11~~	~~10.0[abd]~~ (5.~~2)~~ ~~n=18~~0)	~~8.0[b]~~ (5.2) ~~n=123~~	~~13.6[cd] (11.0) n=46~~(10.9)	~~39.1[bd]~~ (38.~~5)~~ ~~n=27~~7)	~~6.6[a]~~ (5.~~9)~~ ~~n=65~~7)	~~19.1[b]~~ (31.~~2)~~ ~~n=41~~8)	(14.~~0[c] (14.6) n=119~~7)
	n	11	18	121	45	26	65	39	117
mesic (M)	mean	2.8[a]	13.3[ab]	13.2[ab]	14.4[b]	57.2[c]	6.3[ab]	21.3[a]	27.2[b]

mesics (M)	stdev	2.8^{a} (1.3) n=5	12.4^{abc} (16.7) n=(17.6) / 13.2^{b} (37.9) n=113	15.2^{c} (23(38.0) n=39	57.0^{d} (53(21.8) n=34 / 6.5^{ab} (4.1) n=54 / 20.9^{a} (32.6) n=53	27.6^{b} (51(53.4) n=101	(3.5)	(33.2)	(50.8)
	n	5	15	112	39	33	53	50	101
humic (H)	mean	none	12.1^{ab}	5.6^{a}	7.4^{a}	20.2^{b}	4.3^{a}	13.1^{ab}	11.9^{b}
humics (H)	stdevnone	10.0^{ab} (14.0) n=9--	6.2^{a} (8.3) n=38(15.4)	(7.4^{b} (3.4) n=13	(3.4)	20.7^{b} (14.3) n=177)	4.3^{a} (3.2) n=24	13.4^{ab} (12.7) n=19	12.3^{b} (13.2) n=341)
	n	--	7	38	13	16	24	17	33
fibrous (D & F)	mean	4.5^{a}	14.8^{b}	11.3^{b}	14.8^{b}	58.5^{c}	7.1^{a}	27.0^{a}	22.9^{b}
fibrous (D&F)	stdev	(4.5^{a} (4.4) n=12)	(8.1)	15.5^{b} (8.9) n=22(9.9) / 11.6^{b} (10.0) n=136	14.6^{b} (11.3) n=522)	59.8^{c} (50.0) n=41(47.8)	7.3^{a} (6.4) n=733)	26.7 (36.1) n=477)	23.5 (28.8) n=133(26.9)
	n	12	21	135	51	40	73	54	132
amorphous (M & H)	mean	2.8^{a}	15.8^{a}	14.3^{a}	16.1^{a}	63.2^{b}	7.7^{a}	23.0^{a}	29.9^{b}
amorphous (M&H)	stdev	2.8^{a} (1.3) n=5	15.8^{a} (24.5) n=19(25.3)	14.5^{a} (38.3) n=1194)	16.8^{a} (22.3) n=41(21.0)	63.6^{b} (51.5) n=36	8.0 (5.3)^{a} n=57(4.5)	23.5^{a} (33.2) n=585)	30.5^{b} (52.5) n=105(51.9)
	n	5	18	118	41	35	56	56	105

Table ~~3.~~4. Physical and chemical properties of additional surface horizons. Number of observations, bulk density (g/~~cm2~~cm^3), C (%), N (%), C:N ratio, and thickness (cm) of non-main horizon codes. Values in parenthesis are standard deviations.

Horizon	**N**	**Bulk density (g/~~cm2~~cm^3)**	**Carbon (%)**	**Nitrogen (%)**	**C:N Ratio**	**Thickness (cm)**
ash	14	0.183 (0.155)	38.0 (14.4)	0.84 (0.34)	49 (20)	0.1 (-)
burned organics	99	0.122 (0.142)	38.6 (8.9)	1.07 (0.32)	99 (38)	1.~~6 (~~8 (1.0~~.9~~)
lichen	31	0.034 (0.019)	40.3 (5.9)	0.76 (0.41)	69 (37)	4.1 (3.~~6 (2.2~~1)
litter	16	0.044 (0.018)	41.2 (3.1)	1.55 (0.52)	29 (10)	1.6 (0.9)

Table 5. Data columns found in megaAlaska_v11-2 for ScienceBase.csv. This datafile can be found at https://doi.org/10.5066/P960N1F9: Data Supporting Generalized models to estimate carbon and nitrogen stocks of organic layers in Interior Alaska.

Column Name	Units	Column Description
sampleID	--	The first four characters are based on the region and site. Then there is a space. Next the soil core number, followed by a period, and then the basal depth of the soil horizon.
depth	cm	Basal depth of the soil horizon
Hcode	--	Horizon code as determined from Table 1
Sample	--	Qualitative description of the soil horizon
date	mm/dd/yy	Date sample was taken
thickness	cm	Thickness of the soil horizon
BDall	g/cm^3	Bulk density, all soil
BDfine	g/cm^3	Bulk density, fines (soil particles > 2 mm and roots > 1 cm diameter excluded)
HtAboveMin	cm	Height of each basal depth above the organic-mineral soil boundary
carbon	%	Carbon concentration
nitrogen	%	Nitrogen concentration
13C	‰	Per mil (‰) value of delta ^{13}C
14C	‰	Per mil (‰) value of delta ^{14}C for bulk soil sample
LOI	%	Loss-on-ignition value
volume_method	--	Method used to sample soils volumetrically
region	--	Region within Alaska where the site is located (Figure 1)
site	--	Site where the core was taken
profile	--	Soil profile, or core, number
drainage	--	Soil drainage category (Figure 2)
standage	yrs	Age from last disturbance (fire or thaw)
ageclass	--	N = newly burned (< 5 yrs), Y= young (5-50 yrs), M = mature (>50 yrs)
SurfaceVeg	--	Types of vegetation found on the soil surface
SubbedBD	--	If Y the bulk density is not a measured value. Instead an average value was used.
SubbedC	--	If Y the carbon concentration is not a measured value. Instead an average value was used.
SubbedN	--	If Y nitrogen concentration is not a measured value. Instead an average value was used.
GroupedHcode	--	Horizon codes grouped into fewer categories
GroupedVeg	--	Surface vegetation grouped into fewer categories

Table 6: Data columns found in Site_GPS_coordinates_v2. This datafile can be found at https://doi.org/10.5066/P960N1F9: Data Supporting Generalized models to estimate carbon and nitrogen stocks of organic layers in Interior Alaska.

Column Name	**Description**
Region	Region within Alaska where the site is located (Figure 1)
Region Code	Two letter code for the region
Site	Site where the core was taken
Profile	Which soil profiles are located at this location - all indicates general coordinates for all soil profiles
Latitude	Latitude in decimal degrees
Longitude	Longitude in decimal degrees
Datum	Datum of the coordinates