ABoVE: Alder Shrub Cover and Soil Properties, Alaska, 2019

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Documentation Revision Date: 2022-12-29

Dataset Version: 1

Summary

This dataset holds measures of vegetative cover and soil characteristics for sites in interior Alaska, U.S., along the James W. Dalton Highway (Alaska Route 11). The field data were collected during August in 2018 and 2019 to study the expansion of shrub cover, particularly alders (Alnus spp.) in tundra ecosystems and the potential impact of shrubs on soil properties. Samples were measured along transects at 5- to 10-m intervals. Soil samples were collected and analyzed in the laboratory. Vegetation variables include percent cover of mosses, lichens, graminoid species, shrubs, alder, birch (Betula spp.), and willow (Salix spp.) along with the biomass, size, and age structure of alder. An allometric model to estimate alder biomass was developed. Soil metrics include moisture content, conductivity, bulk density, carbon and nitrogen content and isotope ratios. The data include the maximum annual Normalized Difference Vegetation Index (NDVI) for 2019 and the trend in maximum NDVI for 2000-2020. The data are provided in comma-separated values (CSV) format.

The data was collected by a NASA ABoVE team to study the impact of alder shrub expansion into graminoid tundra in interior Alaska, specifically changes in soil carbon storage and permafrost state. Alder expansion was quantified by combining dendrochronology with an assessment of remote sensing products related to vegetation type and productivity and fire history. Permafrost state was assessed by measuring thaw depth in late August (a proxy for active layer thickness) with a tile probe. Soil properties (horizons, depth to permafrost or parent material, C and N stock) were assessed by collecting soil samples that were analyzed in the laboratory for bulk properties. Soil moisture and conductivity was measured in the field.

The dataset includes two files: a file in comma-separated values (CSV) format holding the data and a field photograph in JPEG image format.

Figure 1. Alder shrubs expanding into graminoid tundra. Coldfoot Valley, Alaska. 2019.

Citation

Pedron, S., A. Welch, R.G. Jespersen, Xiaomei Xu, B. Martinez, Y. Khazindar, N. Fiore, M.L. Goulden, and C.I. Czimczik. 2022. ABoVE: Alder Shrub Cover and Soil Properties, Alaska, 2019. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2120

Table of Contents

1. Dataset Overview

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Project: Arctic-Boreal Vulnerability Experiment

The Arctic-Boreal Vulnerability Experiment (ABoVE) is a NASA Terrestrial Ecology Program field campaign being conducted in Alaska and western Canada, for 8 to 10 years, starting in 2015. Research for ABoVE links field-based, process-level studies with geospatial data products derived from airborne and satellite sensors, providing a foundation for improving the analysis, and modeling capabilities needed to understand and predict ecosystem responses to, and societal implications of, climate change in the Arctic and Boreal regions.

Related Publications

Fiore, N.M, M.L. Goulden, C.I. Czimczik, S.A. Pedron, and M.A.Tayo. 2020. Do recent NDVI trends demonstrate boreal forest decline in Alaska? Environmental Research Letters 15:095007. https://doi.org/10.1088/1748-9326/ab9c4c

Welch, A.M., S.A. Pedron, R.G. Jespersen, X. Xu, Y. Khazindar, N.M. Fiore, M. Goulden, B. Martinez, and C.I. Czimczik. 2022. Implications of alder shrub expansion on tundra soil properties in interior Alaska. Submitted to Journal of Geophysical Research: Biogeosciences

Related Dataset

Fiore, N., S. Pedron, M. Tayo, C.I. Czimczik, and M.L. Goulden. 2021. NDVI, Species Cover, and LAI, Burned and Unburned sites, Interior Alaska, 2017-2018. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1797

2. Data Characteristics

Spatial Coverage: Alaska, USA

ABoVE Reference Locations

Domain: Core
State/Territory: Alaska
Grid cells: Ah001v000, Bh006v004, Bh007v003, Ch041v025, Ch046v022

Spatial Resolution: Samples spaced at 5 to 10 m intervals along 30-m transects

Temporal Coverage: 2018-08-14 to 2019-08-28

Temporal Resolution: One time estimates

Study Areas: Latitude and longitude are given in decimal degrees.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska	-150.714	-149.707	68.019	66.340

Data File Information

The dataset includes two files:

ABoVE_alder_data_2019.csv holds the data in comma-separated values (CSV) format. Variables are listed in Table 1.

ABoVE_alder_photo_2019.jpg (Figure 1) is a photograph, in JPEG format, illustrating the tundra ecosystem dominated by graminoid species with some alder shrubs.

Table 1. Variables in *ABoVE_alder_data_2019.csv*.

Variable	Unit	Description
campaign	YYYY	Year of field sampling
date	YYYY-MM-DD	Date of field sampling
location_id	-	Unique identifier for each sampling location
site	-	Site name
transect	-	Transect number
transect_stop	m	Total distance from transect start
lat	degrees_north	Latitude of transect
long	degrees_east	Longitude of transect
elevation	m	Elevationitude of transect
vwc_20	m3 m^{-3}	Volumetric water content at depth of 20 cm
conductivity_20	mS m^{-1}	Conductivity measured at depth of 20 cm in milliSiemens (mS) per meter
thaw_depth	cm	Depth of unfrozen soil from surface; proxy for active layer thickness
bedrock_depth	cm	Depth to bedrock using a 100-cm probe
stem_density	4 m^{-2}	Number of stems in 0.25-m2 quadrat
parent_material	-	Geological parent material at transect
aspect	-	Terrain aspect at transect
comments	-	Comments about sampling or transect conditions
burn	-	Burn status of transect: Y = yes, N = no
vwc_12	m3 m^{-3}	Volumetric water content at depth of 12 cm
conductivity_12	mS m^{-1}	Conductivity measured at depth of 12 cm in milliSiemens (mS) per meter
c_stock_above_mean	g cm^{-2}	Mean total carbon content in organic soil horizons
c_stock_above_sd	g cm^{-2}	Standard deviation of total carbon content in organic soil horizons
c_stock_above_se	g cm^{-2}	Standard error of total carbon content in organic soil horizons
c_stock_above_n	1	Sample size for total carbon content in organic soil horizons
n_stock_above_mean	g cm^{-2}	Mean total nitrogen content in organic soil horizons
n_stock_above_sd	g cm^{-2}	Standard deviation of total nitrogen content in organic soil horizons
n_stock_above_se	g cm^{-2}	Standard error of total nitrogen content in organic soil horizons
n_stock_above_n	1	Sample size for total nitrogen content in organic soil horizons
organic_thickness	cm	Sum of thickness of all organic soil horizons
cn_mean	1	Mean ratio of total carbon to total nitrogen
cn_sd	1	Standard deviation for ratio of total carbon to total nitrogen
cn_se	1	Standard error for ratio of total carbon to total nitrogen
cn_n	1	Sample size for ratio of total carbon to total nitrogen
d13c_mean	1000^{-1}	Mean stable carbon isotope ratio in delta notation (per 1000)
d13c_sd	1000^{-1}	Starndard deviation of stable carbon isotope ratio in delta notation (per 1000)
d13c_se	1000^{-1}	Standard error for stable carbon isotope ratio in delta notation (per 1000)
d13c_n	1	Sample size for stable carbon isotope ratio in delta notation (per 1000)
d15n_mean	1000^{-1}	Mean stable nitrogen isotope ratio in delta notation (per 1000)
d15n_sd	1000^{-1}	Standard deviation of stable nitrogen isotope ratio in delta notation (per 1000)
d15n_se	1000^{-1}	Standard error for stable nitrogen isotope ratio in delta notation (per 1000)
d15n_n	1	Sample size for stable nitrogen isotope ratio in delta notation (per 1000)
bulk_d_mean	g cm^{-3}	Mean bulk density of soil samples

bulk_d_sd	g cm^{-3}	Standard deviation of bulk density of soil samples
bulk_d_se	g cm^{-3}	Standard error of bulk density of soil samples
bulk_d_n	1	Sample size for bulk density of soil samples
vwc_lab_mean	m3 m^{-3}	Mean volumetric water content measured in laboratory
vwc_lab_sd	m3 m^{-3}	Standard deviation for volumetric water content measured in laboratory
vwc_lab_se	m3 m^{-3}	Standard error for volumetric water content measured in laboratory
vwc_lab_n	1	Sample size for volumetric water content measured in laboratory
basal_d	cm	Basal diameter of alder (*Alnus viridis*)
biomass_mod_stem	kg	Modeled mean dry biomass of an individual alder plants
biomass_mod_stem_sd	kg	Standard deviation for modeled mean dry biomass of an individual alder plants
biomass_mod_stem_se	kg	Standard error for modeled mean dry biomass of an individual alder plants
biomass_mod_stem_n	kg	Sample size for modeled mean dry biomass of an individual alder plants
biomass_mod	kg m^{-2}	Modeled dry biomass of alders per area
biomass_mod_se	kg m^{-2}	Standard error for modeled dry biomass of alders per area
biomass_mod_n	kg m^{-2}	Sample size for modeled dry biomass of alders per area
biomass_c_mod	kg C m^{-2}	Modeled carbon content of alders per area
biomass_c_mod_se	kg C m^{-2}	Standard error for modeled carbon content of alders per area
biomass_c_mod_n	kg C m^{-2}	Sample size for modeled carbon content of alders per area
biomass	kg	Observed mean dry biomass of an individual alder plants
ndvi_max_trend	1 y^{-1}	Trend (slope) of yearly maximum Normalized Difference Vegetation Index (NDVI) over 2000-2020 for transect
ndvi_max_2019	NDVI	Maximum NDVI for 2019
age_mean	y	Mean maximum age of alder along transect
age_sd	y	Standard deviation of maximum age of alder along transect
age_se	y	Standard error of maximum age of alder along transect
age_n	1	Sample size for maximum age of alder along transect
percent_bare_mean	percent	Mean coverage of bare ground
percent_bare_sd	percent	Standard deviation of coverage of bare ground
percent_bare_se	percent	Standard error of coverage of bare ground
percent_bare_n	1	Sample size for coverage of bare ground
percent_moss_mean	percent	Mean coverage of mosses
percent_moss_sd	percent	Standard deviation of coverage of mosses
percent_moss_se	percent	Standard error of coverage of mosses
percent_moss_n	1	Sample size for coverage of mosses
percent_lichen_mean	percent	Mean coverage of lichens
percent_lichen_sd	percent	Standard deviation of coverage of lichens
percent_lichen_se	percent	Standard error of coverage of lichens
percent_lichen_n	1	Sample size for coverage of lichens
percent_dwarf_shrub_mean	percent	Mean coverage of dwarf shrubs
percent_dwarf_shrub_sd	percent	Standard deviation of coverage of dwarf shrubs
percent_dwarf_shrub_se	percent	Standard error of coverage of dwarf shrubs
percent_dwarf_shrub_n	1	Sample size for coverage of dwarf shrubs
percent_graminoid_mean	percent	Mean coverage of graminoid species
percent_graminoid_sd	percent	Standard deviation of coverage of graminoid species

percent_graminoid_se	percent	Standard error of coverage of graminoid species
percent_graminoid_n	1	Sample size for coverage of graminoid species
percent_alder_mean	percent	Mean coverage of alder
percent_alder_sd	percent	Standard deviation of coverage of alder
percent_alder_se	percent	Standard error of coverage of alder
percent_alder_n	1	Sample size for coverage of alder
percent_willow_mean	percent	Mean coverage of willow (*Salix* spp.)
percent_willow_sd	percent	Standard deviation of coverage of willow
percent_willow_se	percent	Standard error of coverage of willow
percent_willow_n	1	Sample size for coverage of willow
percent_aspen_mean	percent	Mean coverage of aspen (*Populus* spp.)
percent_aspen_sd	percent	Standard deviation of coverage of aspen
percent_aspen_se	percent	Standard error of coverage of aspen
percent_aspen_n	1	Sample size for coverage of aspen
percent_paper_birch_mean	percent	Mean coverage of paper birch (*Betula neoalaskana*)
percent_paper_birch_sd	percent	Standard deviation of coverage of paper birch
percent_paper_birch_se	percent	Standard error of coverage of paper birch
percent_paper_birch_n	1	Sample size for coverage of paper birch
percent_alder_max_mean	percent	Mean of the maximum coverage of alder observed among upper, middle, and lower vertical strata
percent_alder_max_sd	percent	Standard deviation of maximum coverage of alder observed among all three vertical strata
percent_alder_max_se	percent	Standard error of maximum coverage of alder observed among all three vertical strata
percent_alder_max_n	1	Sample size for maximum coverage of alder observed among all three vertical strata
percent_alder_upper_mean	percent	Mean coverage of alders in stratum ≥2 m above ground
percent_alder_upper_sd	percent	Standard deviation of coverage of alders in stratum ≥2 m above ground
percent_alder_upper_se	percent	Standard error of coverage of alders in stratum ≥2 m above ground
percent_alder_upper_n	1	Sample size for coverage of alders in stratum ≥2 m above ground
percent_alder_mid_mean	percent	Mean coverage of alders in stratum 1 to 2 m above ground
percent_alder_mid_sd	percent	Standard deviation of coverage of alders in stratum 1 to 2 m above ground
percent_alder_mid_se	percent	Standard error of coverage of alders in stratum 1 to 2 m above ground
percent_alder_mid_n	1	Sample size for coverage of alders in stratum 1 to 2 m above ground
percent_alder_lower_mean	percent	Mean coverage of alders in stratum <1 m above ground
percent_alder_lower_sd	percent	Standard deviation of coverage of alders in stratum <1 m above ground
percent_alder_lower_se	percent	Standard error of coverage of alders in stratum <1 m above ground
percent_alder_lower_n	1	Sample size for coverage of alders in stratum <1 m above ground
shrub_size_coverage	-	Binary categorical variable which indicates the presence of shrubs >2 m in height. Values: ">2" (tall shrubs present) or "<2" (tall shrubs absent).
shrub_size_biomass	-	Binary categorical variable which indicates whether modeled alder biomass was >2 kg m^{-2}. Values: ">2" (biomass >2 kg m^{-2}) or "<2" (biomass <2 kg m^{-2}) .

3. Application and Derivation

The data documents the expansion of alder shrubs into graminoid tundra in interior Alaska over the past decades, a land cover change process observed across the Arctic. While many studies have documented this phenomenon, this dataset was obtained to study the implications of alder shrub expansion on soil properties, such as active layer thickness and the storage of carbon and nitrogen in soils and biomass. The data indicates that the expansion of alder shrubs results in the loss of organic soil horizons and a deeper thaw of minerals. Thus, alder shrub expansion contributes to the degradation of permafrost and reduces the amount of carbon stored in Arctic soils.

4. Quality Assessment

Measured variables are provided with mean, standard deviation, standard error, and sample size.

5. Data Acquisition, Materials, and Methods

Shrub biomass data and soil samples were collected at five alpine tundra sites in interior Alaska along the James W. Dalton Highway (Alaska Route 11) during August in 2018 and 2019. Sites were selected to minimize differences in vegetation composition, aspect, and parent material. At each site, three parallel 30-meter transects were established, separated by 10 m, incorporating areas of higher and lower shrub density. GPS location and elevation, and active layer thickness were recorded every 5 m along transects.

Vegetation height, cover, and composition were determined along each transect in 10-m intervals. The proportional cover of alder (*Alnus viridis* (CHAIX) DC.) within two canopy layers (<2 m and ≥2 m), along with ground cover, were recorded at 10-m intervals. Vegetations and cover types included dwarf shrub, graminoid, moss, lichen, and bare soil. For each location, alder height was estimated based on the presence or absence of alder in the canopy. All locations with alder ≥2 m tall also had shorter alders present. For locations overlapped by two surveys (i.e. 10 and 20 m), presence/absence data was averaged. Additionally, the maximum alder coverage (*percent_alder_max*) was estimated at each location as the greater proportional alder coverage of the two canopies. Where two surveys overlapped, the *percent_alder_max* value was averaged.

User Note: In this dataset, the canopy layer <2 m is separated into two strata: *percent_alder_mid* (1-2 m) and *percent_alder_lower* (0-1 m). However, these two strata were combined in the analysis presented in Welch et al. (2022).

Alder biomass was quantified by recording the number of alder stems within a 0.5 m × 0.5 m grid every 5 m along each transect and measuring the basal diameter of each stem. An allometric relationship between biomass and basal stem diameter, based on harvesting of 5-6 representative stems (including foliage) at sites 2-4, was developed to estimate aboveground biomass.

Alder growth history was reconstructed from basal stem desks collected from multiple individuals in each transect.

To study alder expansion over time, trends in NDVI over 2000-2020 were measured. NDVI trends were derived from Landsat Collection 1 (Tiers 1 and 2; https://www.usgs.gov/landsat-missions/landsat-collection-1). Images were extracted for Julian days 152-243 of years 2000-2020 using the Google Earth Engine Python API (2000 to 2020), filtered for clouds, snow, water, band saturation, and geometric uncertainty. Landsat NDVI was calculated for each image using the red and infrared bands from each sensor (bands 3 and 4 for Landsat 5 and 7; bands 4 and 5 for Landsat 8). Maximum NDVI (*ndvi.max*) was taken as the maximum observation per year per site, based on a minimum of 7 observations per year.

Soil cores were collected with an electric auger with a scalloped edge and an inner diameter of 2.54 cm to a depth of 6 to 36 cm below the surface, determined by the distance to frozen or saturated ground, parent material, or auger length. Cores were stored intact in capped plastic liners and frozen (-20° C) within 24 hours until analysis. Frozen soils were sectioned by horizon, and oven-dried at 60° C at University of California at Irvine. Organic and mineral samples were homogenized to <40 µm diameter or ground to powder, respectively. Aliquots (1-6 mg of organic and 8-25 mg of mineral soil) were weighed into tin capsules and analyzed for their total C and N content with an elemental analyzer coupled with an isotope ratio mass spectrometer.

See Welch et al. (2022) for more details of methods and the findings of this study.

6. Data Access

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

ABoVE: Alder Shrub Cover and Soil Properties, Alaska, 2019

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

Fiore, N.M, M.L. Goulden, C.I. Czimczik, S.A. Pedron, and M.A.Tayo. 2020. Do recent NDVI trends demonstrate boreal forest decline in Alaska? Environmental Research Letters 15:095007. https://doi.org/10.1088/1748-9326/ab9c4c

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