Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

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Volume 125
BOREAS TE-1 Soils Data over the SSA Tower Sites in Raster Format

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Summary
The BOREAS TE-1 team collected various data to characterize the soil-plant systems in the BOREAS SSA. This data set was gridded from vector layers of soil maps that were received from Dr. Darwin Anderson (TE-1), who did the original soil mapping in the field during 1994. The vector layers were gridded into raster files that cover approximately 1 square kilometer over each of the tower sites in the SSA.

Note that some of the data set files on the BOREAS CD-ROMs have been compressed using the Gzip program. See Section 8.2 for details.

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1. Data Set Overview

1.1 Data Set Identification
BOREAS TE-01 Soils Data over the SSA Tower Sites in Raster Format

1.2 Data Set Introduction
This data set contains soil properties and classification information over the BOREal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA) tower sites. They were gridded to a 10-meter pixel resolution for each of the tower sites. The data were reprojected into the Albers Equal-Area Conic (AEAC) projection from the original maps made by Dr. Darwin Anderson's BOREAS Terrestrial Ecology (TE)-01 science team (University of Saskatchewan).

1.3 Objective/Purpose
This data set has been processed to provide raster files that can be used for modeling or for comparison purposes. The purpose of this data set is to provide information about the spatial distribution of soils and their characteristics in proximity to the SSA tower sites.
1.4 Summary of Parameters

This data set contains information about the spatial distribution of soil classes around the SSA tower sites along with soil class properties such as parent material, texture, slope class, and water table depth. A detailed list of parameters is given in Section 7.

The polygon numbers in the American Standard Code for Information Interchange (ASCII) table files correspond to pixel values in the binary raster files. The value of each pixel can be linked with the table described in Section 7 in order to extract the soil parameters.

1.5 Discussion

This data set was originally produced as a set of vector layers by Dr. Anderson. Aerial photography and field methods were used to identify various soil polygons for the tower sites (Old Black Spruce (OBS), Old Jack Pine (OJP), Young Jack Pine (YJP), Fen, and Old Aspen (OA)).

1.6 Related Data Sets

BOREAS TE-20 Soils Data over the NSA-MSA and Tower Sites in Raster Format
BOREAS TE-20 Soils Data over the NSA-MSA and Tower Sites in Vector Format
BOREAS TE-20 NSA Soils Lab Data
BOREAS TE-01 SSA Soils Lab Data

2. Investigators

2.1 Investigator Name and Title

Dr. Darwin Anderson
Department of Soil Science
University of Saskatchewan

2.2 Title of Investigation

Soils of Tower Sites in the Southern Study Area

2.3 Contact Information

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3. Theory of Measurements

The original soils mapping was performed by using a combination of field samples of the soil and aerial photographs. This digital map data set provides investigators with a continuous surface of soil parameters that can be used for modeling purposes at the tower sites in the SSA.

4. Equipment

4.1 Sensor/Instrument Description

In addition to field techniques, aerial photography was used to map the soils at the tower sites. No additional information is available about this photography.

4.1.1 Collection Environment

The original vector files were received in digital line graph (DLG) format from Dr. Anderson.

4.1.2 Source/Platform

Unknown.

4.1.3 Source/Platform Mission Objectives

Unknown.

4.1.4 Key Variables

The key variables of this data set include:

- POLYNUM = Polygon number
- GRIDLOC = Grid location
- COMPONT = Polygon component (landscape element)
- NUMBER = Component rank number
- PERCENT = Percentage distribution of components
- KINDMAT = Kind of rock outcrop or other material at the surface
- LANDFRM = Local surface form
- PMDEPO1 = Mode of deposition or origin of first (upper) parent material
- TXTURE1 = Texture of first (upper) parent material
- TXTMOD1 = Texture modifier of first (upper) parent material
- PMDEPO2 = Mode of deposition or origin of second (middle) parent material
- TXTURE2 = Texture of second (middle) parent material
- TXTMOD2 = Texture modifier of second (middle) parent material
- PMDEPO3 = Mode of deposition or origin of third (lower) parent material
- TXTURE3 = Texture of third (lower) parent material
- TXTMOD3 = Texture modifier of third (lower) parent material
- COFRAGS = Coarse fragment content in control section of mineral soils
- SLOPE = Slope gradient class
- DRAINAGE = Drainage class
- DEPTHWT = Depth to water table, average
- PFDDISTR = Permafrost distribution or occurrence
- DPTHACT = Depth of active layer (average)
- ICECTNT = Ice content of permanently frozen layer
- DPTHLFH = Thickness of humus layer (LFH)
- DPTHORG = Average thickness of peat deposit
- SOILDEV = Soil development (soil classification)
- VARIANT = Classification variant or phase
- SOILTP1 = Dominant soil type associated with polygon component
- SOILPH1 = Soil phase or variant associated with dominant soil type
- SOILTP2 = Subdominant soil type associated with polygon component
- SOILPH2 = Soil phase or variant associated with subdominant soil type
4.1.5 Principles of Operation
Unknown.

4.1.6 Sensor/Instrument Measurement Geometry
Unknown.

4.1.7 Manufacturer of Sensor/Instrument
Unknown.

4.2 Calibration

4.2.1 Specifications
Unknown.

4.2.1.1 Tolerance
Unknown.

4.2.2 Frequency of Calibration
Unknown.

4.2.3 Other Calibration Information
Unknown.

5. Data Acquisition Methods

The accuracy of the following information is not known. The following describes the aerial photos that were known to be available to the person who digitized the soils maps. However, they may not be the photos from which the actual soil polygon mapping was done.

OBS site photos were taken on 20-Aug-1971 and are at a scale of 1:78,000. The photo number is A22429. The OA photo number is A27617. They were taken in 1991 and are at a scale of 1:12,500 for the Prince Albert National Park (PANP). The OJP, YJP, and Fen photos were taken 22-Jul-1964. They are at a scale of 1:12,500. Although this has not been confirmed, they appear to be from Energy, Mines, and Resources in Canada.

6. Observations

6.1 Data Notes
None given.

6.2 Field Notes
The following soil descriptions at the tower sites were provided by TE-01 personnel.

SSA-OBS
The BOREAS SSA-OBS site is located northeast of Prince Albert, Saskatchewan, Canada. Specifically, the entrance to the OBS site is approximately 38 km (23.5 miles) north of the SSA Operations Center, located at the southern end of Candle Lake. This site can also be found by traveling approximately 8 km (5 miles) north of White Gull Lake.

Soils north of Prince Albert generally have parent materials that are the result of Pleistocene glaciation (Anderson and Ellis, 1976). This area is no exception, with parent materials including glaciofluvial, glaciolacustrine, and glacial till deposits. In some areas, aeolian deposits cover the parent materials. Within these parent materials, stoniness ranges from occasional pockets and lenses of gravel...
to areas that are relatively stone free. The Prince Albert soil survey (Anderson and Ellis, 1976) identified the OBS site as a Flat Bog with Bittern Lake soils. Flat Bog soils in the area have 40 to 100 cm of forest peat over sandy to gravelly materials and stony glacial till.

The soils of the OBS site vary significantly. The soils range from Eluviated Eutric Brunisols to Gleyed Cumulic and Cumic Humic Regosols. The wetter areas have organic soils that are mainly Mesic and Typic Miresols and Mesic and Typic Fibrisols. Peat in the area ranges from 10 to 160 cm in thickness, with an average thickness of 45 cm. The average total carbon of the site is 24.33%. The average pH at the OBS site is 8.02. Gray Luvisol and Gleyed Gray Luvisol soils occur on low ridges with sandy to gravelly deposits over glacial till. The average bulk density of the soils in the study site is 1.1.

Vegetation includes mainly black spruce with occasional jack pine, tamarack, and trembling aspen. There are areas with significant amounts of stunted black spruce found mainly on deeper organic soils. In polygon 22, aspen, white spruce, paper birch, and balsam fir are present. This is the only area where these species existed. Polygon 14 is the driest area, illustrated through the dominance of jack pine in the area. Ground cover in the study site includes feather moss, sphagnum moss, labrador tea, lichen, bunchberry, prickly rose, and various other species of mosses. The average electrical conductivity is 235.88 Siemens/cm, which is slightly higher than the dry, sandy jack pine site, but is not indicative of soil salinity.

SSA-OJP

The SSA-OJP site is situated northeast of Prince Albert, approximately 5 km (3.1 miles) west and 2.5 km (1.5 miles) north of the southern junction of Highway 106 and Highway 120. This area is located in the southern part of the Nipawin Provincial Park.

Soils of the Prince Albert area generally have parent material related to Pleistocene glaciation. The most common Pleistocene deposits in the area are glacial, glaciolacustrine, glaciofluvial, or outwash materials. This study site is typical, with most parent materials being glaciofluvial, with occasional lacustrine soils present. The only significant difference occurs in polygon 1, which has numerous aeolian deposits.

This site is dominantly Brunisolic soils, but Regosolic and Gleysolic soils are also present. These soils are developed from coarse textured weakly to noncalcareous glaciofluvial, glaciolacustrine, and aeolian deposits. The most common soil series found are weakly developed Eluviated Eutric Brunisols but Orthic Eutric Brunisols, Gleyed Orthic Eutric Brunisols, and Orthic Regosols are also present.

Polygon 3 differs in that significantly modified Eluviated Eutric Brunisols are present. In this area, there are coarse textured, sandy glaciolacustrine deposits that have finer textured deposits within the soil profile. These bands are made up of clay and silt of various content. This layering of sediments may be the result of water or perhaps wind deposition. The significance of these bands is that the comparatively small amounts of clay present act as a barrier to water moving downward through the soil. As a result, there are many species of plants growing in the area that would not normally be found in areas with this soil type.

Typical vegetation for this area includes a mature stand of jack pine and alder with an underbrush consisting mainly of reindeer moss, bearberry, and blueberry. The alders tend to be concentrated around small depressions, but are often found in dense concentrations where several clay bands and/or finer textured sand occur. The capacity of a soil to support plant life is greatly influenced by the ratio of carbon to nitrogen in the soil. The average reading for the carbon-to-nitrogen ratio for the OJP site is 14.24. A large amount of vegetation cover typically leads to the development of an LFH layer. This study site is no exception. The strongly acidic nature of pine soils can be illustrated through pH readings of the LFH layer. In this study site, the average pH of the LFH layer is 4.72. The average amount of total carbon in the LFH layer 25.07%, while the average amount of inorganic carbon located in the LFH layer is 0.66. The soils in the area have a much lower average amount of carbon. The total average organic carbon in the A, B, and C horizons is 0.18, while the total average inorganic carbon for the A, B, and C horizons is 0.08.

The amount of salt in a soil can also severely affect the capacity of the soil to support plant life. A measure of electrical conductivity can illustrate the amounts of salt in a soil and what effect these amounts will have on the ability of the soil to support plant life. The average reading of electrical
conductivity for the OJP site is 32.63 Siemens/cm, indicating extremely low salt content. It should be noted that a ratio of 1:1 was used for mineral soils, while a ratio of 1:5 was used for organic soils.

Other factors that can influence the amount of plant life a soil can support are the amount of nitrogen, phosphorus, and sulfur found in the soil. The pine soils of the OJP site have an average nitrogen content of 639.7 mg/kg. The average amounts of phosphorus and sulfur are 194.13 mg/kg and 63.61 mg/kg, respectively.

SSA-Fen

The SSA-Fen site is located northeast of Prince Albert approximately 58 km (36 miles) east of Prince Albert on Highway 55 and 38 km (23.6 miles) north on Highway 106. The site is south of where White Gull Creek intersects Highway 106.

Soils north of Prince Albert generally have parent materials resulting from Pleistocene glaciation (Anderson and Ellis, 1976). The most common Pleistocene deposits in the area are glacial till, glaciolacustrine, lacustrine, and outwash materials. This study site is an exception in that organic soils dominate, although the mineral substrata are a sandy glacial outwash. A published soil map shows the Fen study site, including Flat Bog, with about 0.5 to 1.0 meters of forest peat over sandy materials. This area grades to an area of Patterned Fen (FP) in the central portion, where peat thicknesses are greater. Organic soils form from partially decayed residues of plants that accumulate in wet or poorly drained depressions. This is evident in the accumulation of peat in the area. The depth of peat ranges from 20 to 330 cm, with the average peat thickness being 1.25 meters. The peat is mainly organic materials, which results in the high amounts of carbon found in the fen samples. The average amount of organic carbon found in the samples is 37.23%. Organic soils found in the Fen study site include Terric, Typic, and Fibric Mesisols, Fibrisols, and Humisols. Although most of the soils in the study area are organic, some mineral soils are present. Organic soil types include Rego-Gleysol, Cumulic Humic Regosol, Eluviated Eutric Brunisol, and Orthic Regosols. These soils are all within the Pine Association.

The landscape of the area ranges from flat to very gently sloping peatland. Moss hummocks form the only localized relief in the study site. The most notable exceptions to this localized relief are in polygons 27 and 28, where approximately 15% of the area is standing water. Another localized anomaly is the abundance of deadfall in polygon 12. An interesting anomaly occurs in polygon 2, where one soil pit has organic material approximately 1 meter thick underlain by clay. Under this clay band is a deep green sand. This unusual soil occurs only in one soil pit.

The vegetation of the area includes tamarack, black spruce, and swamp birch. Ground cover includes such species as labrador tea, sphagnum, sedges, feather moss, reindeer moss, and bearberry.

Many factors can affect the ability of a soil to support vegetation, including the amounts of nitrogen, phosphorus, and sulfur and the pH of the soil. The average pH in the Fen study site soil is 5.35. The average contents of nitrogen, phosphorus, and sulfur are 16245.13 mg/kg, 1332.63 mg/kg, and 1430.93 mg/kg, respectively. The total average carbon available in the soil is 32.44%. The total average organic carbon is 29.42%, while the total average inorganic carbon is 3.02%.

SSA-OA

The SSA-OA site is located northeast of Prince Albert, approximately 20 km (12 miles) west and 5 km (3 miles) north of the resort community of Emma Lake on Highway 263 35 km (22 miles) north of Prince Albert on Highway 2, and 21 km (13 miles) east on highway 263. This location puts the site in the southeastern part of the PANP.

Soils north of Prince Albert generally have parent materials that are the result of Pleistocene glaciation. The most common Pleistocene deposits in the area are glacial till, glaciolacustrine, glaciofluvial, or outwash materials. The parent materials of the soils in this study area are mainly glacial till with some local areas of glaciolacustrine deposits.

Gray Luvisols of the Waitville Association dominate the soils in this area. Terric Mesisols and Typic Fibrisols form a subdominant component of the soils and are located in polygons 5, 8, 16, and 18.

A notable exception occurs in polygon 1. In this area, the soils are generally sandy. The presence of clay bands makes the soil in these areas significantly different from other soils in the study area.
These clay bands act as a barrier preventing rapid drainage normally associated with this soil, which results in the survival of plant species in soils that typically do not support that type of plant life. This situation also occurs in polygon 5. All soils at the OA site have LFH layers range in thickness from 4 to 50 cm. The average depth of the LFH layer is 20 cm. More details on the carbon and nutrient content of the LFH or D layers are available in a research paper by W.Z. Huang and J.J. Schoenau (Can. Journal of Soil Science, 76: 373-385).

Bulk density of a soil also affects the capacity of that soil to sustain plant life. Bulk density is the measure of the mass of a unit volume of dry soil. This measure includes both the solids and the pores located in the soil. Thus, soils that are loose and porous have a low bulk density, while soils that are more compact have a high bulk density (Brady, N.C. The Nature and Property of Soils). Soils in the OA study site have an average bulk density of 1.44 for the A, B, and C horizons and 0.13 for the LFH layer.

The landscape of the area ranges from undulating to dissected. Trembling aspen is the dominant tree species in the study area, with occasional white spruce, balsam poplar, and white birch also present. The ground cover includes hazelnut, prickly rose, feather moss, sphagnum moss, lily of the valley, grass, and wild red raspberry. Some sedges and thistle are found in polygon 9. The vegetation of the area can be affected by factors such as electrical conductivity; pH of both the LFH layer and the remainder of the soil; the carbon-to-nitrogen ratio; the amount of organic and inorganic carbon; and the amounts of nitrogen, phosphorus, and sulfur in the soil. The soils of the OA site have an average of 6771.4 µg/ml of nitrogen, 758.5 µg/ml of phosphorus, and 669.5 µg/ml of sulfur, respectively.

The soils of the OA site have an electrical conductivity reading of 332.81 Siemens/cm. It should be noted that these samples were taken using a 1:1 ratio for mineral soils and a 1:5 ratio for organic soils.

**SSA-YJP**

The SSA-YJP site can be found northeast of Prince Albert, Saskatchewan, Canada. The YJP study area is approximately 2.5 km (1.5 miles) west and 2.5 km (1.5 miles) south of the southern junction of Highway 106 and Highway 120 in the southern section of the Nipawin Provincial Park.

Soils of the Prince Albert area generally have parent materials related to Pleistocene glaciation (Anderson and Ellis, 1976). The most common Pleistocene deposits in the area are glacial, glaciolacustrine, lacustrine, or outwash materials. This site is typical, with the parent material consisting of gravelly to sandy glaciofluvial and some sandy glaciolacustrine deposits. There are also areas where aeolian deposits are present. The soil in the study site has an average bulk density of 0.75.

The most common soils found are Brunisols, with Regosols also present. The soil also has an LFH layer ranging from 1 to 3 cm in thickness. The average thickness of the LFH layer is 2.2 cm.

Vegetation in the area consists of jack pine (both young and old) and alders. The ground cover consists of grass. The landscape is undulating, with a gentle slope ranging from 3 to 5%. Polygons 2, 3, and 4 are areas of former logging activity and are dominated by piles of wood shavings. Therefore, they are classified as Anthropogenic, and no data were collected in these areas.

Another measure of the productivity of a soil is the amount of nitrogen, phosphorus, and sulfur present. The A horizon of the YJP study site has an average of 917.6 mg/kg, 246.6 mg/kg, and 100.7 mg/kg of nitrogen, phosphorus, and sulfur, respectively.

The rapidly drained sandy soils contain low concentrations of soluble salts, with average readings for the electrical conductivity of either 1:1 for mineral soils or 1:5 for organic soils (soil, water, w/v). The average reading of electrical conductivity is 76 Siemens/cm.

The LFH layer contains, on average, 21.2% organic carbon and has a carbon-to-nitrogen ratio of 13.22, indicating that the ecosystem is limited by the amount of nitrogen. There is low carbon storage in the mineral soil, with mean C content of 0.25% for the A and B horizons.

One final element that can influence the capacity of a soil to sustain plant life is the pH of a soil. The pH of the soil at the YJP site is 5.17. The average carbon-to-nitrogen ratio is 13.22.
7. Data Description

7.1 Spatial Characteristics
The soil maps in this data set vary in their resolution and coverage. These details are given in the following sections.

7.1.1 Spatial Coverage
The area mapped is projected in the AEAC projection and is bounded by the following points. These coordinates are based on the North American Datum of 1983 (NAD83).

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7.1.2 Spatial Coverage Map
Not available.
7.1.3 Spatial Resolution
These data were gridded from their original vector form to a pixel resolution of 10 meters.

7.1.4 Projection
The area mapped is projected in the ellipsoidal version of the AEAC projection. The projection has the following parameters:

Datum: NAD83
Ellipsoid: GRS80 or WGS84
Origin: 111.000°W 51.000°N
Standard Parallels: 52° 30' 00"N
58° 30' 00"N
Units of Measure: kilometers

7.1.5 Grid Description
These images are projected as the AEAC projection. The parameters for this projection are described in Section 7.1.4.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
Field samples for mapping the Modeling Sub-Area (MSA) and tower sites were collected in 1994. Aerial photos were used for extending the field samples to map the areas around the towers. The exact scale and dates of the aerial photography are not known.

OBS site photos were taken on 20-Aug-1971 and are at a scale of 1:78,000. The photo number is A22429. The OA photo number is A27617. They were taken in 1991 and are at a scale of 1:12,500. They were taken for the PANP. The OJP, YJP, and Fen photos were taken 22-Jul-1964. They are at a scale of 1:12,500 and appear to be from Energy, Mines, and Resources in Canada. Information about any aerial photos used for the Fen and YJP sites is unknown.

7.2.2 Temporal Coverage Map
Not available.

7.2.3 Temporal Resolution
These data represent an assessment of the soils at the BOREAS SSA tower sites in 1994.

7.3 Data Characteristics
This data set is in an image format in which the value of a pixel represents the polygon number from the original vector data. This number can be related to a set of records in the ASCII soils table files. The soils table files contain parameters for the various polygons. There is a separate soils table for each map.

7.3.1 Parameter/Variable
POLYNUM
GRIDLOC
COMPONT
NUMBER
PERCENT
KINDMAT
LANDFRM
PMDEPO1
TEXTURE1
TXTMOD1
PMDEPO2
7.3.2 Variable Description/Definition

Binary Raster Image files:

POLYNUM: Number of the map polygon to which the pixel belongs. Unitless but coded value.

ASCII Soil Table Files:

1. POLYNUM = Number of the map polygon.

2. GRIDLOC = An alphanumeric grid to be used to find a particular polygon on the map.

3. COMPONT = Polygon component (landscape element).

The landscape components that make up the area delineated by the polygon. A polygon may have one or many components. They are listed in order of extent.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Dominant</td>
<td>The D components combined cover &gt;50% of the land area of a polygon.</td>
</tr>
<tr>
<td>S</td>
<td>Subdominant</td>
<td>The S components combined cover &lt;50% of the land area of a polygon.</td>
</tr>
<tr>
<td>I</td>
<td>Inclusion</td>
<td>Each inclusion covers &lt;15% of the polygon, but the combined area of inclusions may be 25%.</td>
</tr>
<tr>
<td>W</td>
<td>Water</td>
<td>Surface water in the form of lakes, ponds, or streams may cover between 5 and 100% of a polygon.</td>
</tr>
</tbody>
</table>
4. **NUMBER** = Component rank number.

Landscape elements with similar parent material properties are considered to belong to the same general component. Thus, these elements together form the dominant or subdominant component in the polygon, but the individual elements will not be dominant or subdominant. To show the landscape relationship or parent material association all the elements are considered to belong to the dominant (D) or subdominant (S) group, but they are ranked D1, D2, etc., according to their relative importance within the group. For example, three drainage conditions exist on a gently undulating glaciolacustrine blanket. The well-drained portion occupies 30% of the polygon area, imperfectly drained conditions exist in 15% of the polygon, and poorly drained areas with a thin peat cover occupy an additional 10%, for a combined total of 55%. This makes this grouping the dominant component in the polygon. Thus, these three elements will be labeled D1, D2, and D3 respectively.

In the cases of inclusions (I) and water (W), the rank numbers link these components either to the dominant or to the subdominant components. The convention is that an uneven rank number (1, 3, ...) links the inclusion or water to the dominant component(s), while an even rank number links it to the subdominant component(s).

5. **PERCENT** = Percentage distribution of components.

Percent area is estimated within the nearest 5%. Components <10% are not listed except for W.

6. **KINDMAT** = Kind of rock outcrop or other material at the surface.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>Organic soil</td>
<td>Contains &gt;30% organic matter by weight</td>
</tr>
<tr>
<td>R2</td>
<td>Hard rock, acidic</td>
<td>Dominant mineral particles, contains &lt;30% organic matter by weight</td>
</tr>
<tr>
<td>SO</td>
<td>Mineral soil</td>
<td>Water</td>
</tr>
<tr>
<td>WA</td>
<td>Water</td>
<td></td>
</tr>
</tbody>
</table>

7. **LANDFRM** = Local surface form.

Mineral surface forms. Two classes may be combined; for example, "bh" is hummocky blanket, and "vi" is inclined veneer.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>blanket</td>
<td>Unconsolidated surficial materials &gt;1 m thick.</td>
</tr>
<tr>
<td>d</td>
<td>dissected</td>
<td>Gullies or valleys dissect the component.</td>
</tr>
<tr>
<td>h</td>
<td>hummocky</td>
<td>A complex sequence of slopes extending from concavities of various sizes to knolls or short, discontinuous ridges.</td>
</tr>
<tr>
<td>i</td>
<td>inclined</td>
<td>A sloping, unidirectional surface with a generally constant slope not broken by marked irregularity or gullies.</td>
</tr>
<tr>
<td>k</td>
<td>knoll and kettle</td>
<td>A very chaotic sequence of knolls.</td>
</tr>
</tbody>
</table>
l  level  A flat or very gently sloping unidirectional surface with a generally constant slope not broken by marked elevations and depressions; slopes are generally <2%.

r  ridged  A long, narrow elevation of the surface, usually distinctly crested with steep sides.

s  steep  Erosional slopes on both consolidated and unconsolidated materials.

u  undulating  A regular sequence of gentle slopes that extends from rounded and, in some places, confined concavities to broad, rounded convexities; low local relief with slopes usually between 2 and 5%.

v  veneer  Unconsolidated surficial materials <1 m thick. Veneers may be continuous or patchy.

w  beach, strandline  Low ridges with steeper slope on one side than on the other.

y  subdued hummocky  A complex sequence of slopes extending from concavities of various sizes to knolls. Local topography is < 10 m.

Organic Surface Forms.

The classification of landforms is often a case of "best fit." Frequently, the landform encountered does not quite meet all criteria of any class. Organic landforms often are intergrades of one form to another.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ba</td>
<td>Palsa bog</td>
<td>A bog composed of individual or coalesced palsas, occurring in an unfrozen peatland. Palsas are mounds of perennially frozen peat and mineral soil, up to 5 m high, with a maximum diameter of 100 m. The surface is highly uneven, often containing collapse scar bogs.</td>
</tr>
<tr>
<td>Bc</td>
<td>Collapse scar bog</td>
<td>A circular or oval-shaped wet depression in a perenni ally frozen peatland; the collapse scar bog was once part of the perennially frozen peatland, but the permafrost thawed, causing the surface to subside; the depression is poor in nutrients, as it is not connected to the minerotrophic fens in which the palsa or peat plateau occurs.</td>
</tr>
</tbody>
</table>
| Bt   | Peat plateau bog       | A bog composed of perennially frozen peat, rising abruptly about 1 m from the surrounding unfrozen fen; the surface is relatively flat and even, and the bog commonly covers large areas; the peat was
originally deposited in a nonpermafrost environment and is associated in many places with collapse bogs or fens.

A bog occurring on gently sloping terrain underlain by generally discontinuous permafrost; although drainage is predominantly below the surface, overland flow occurs in poorly defined drainage-ways during peak runoff; peat thickness is usually less than 1.5 m.

A fen occupying a topographically defined basin; however, the basins do not receive drainage from upstream, and the fens are thus influenced mainly by local hydrological conditions; the depth of peat increases toward the center.

A fen with circular or oval depressions, up to 100 m in larger fens, marking the subsidence of thawed permafrost peatlands. Dead trees, remnants of the subsided vegetation of permafrost peatlands, are often evident.

A fen with a very gently sloping featureless surface; this fen occupies broad, often ill-defined depressions, and may be interconnected with other fens; peat accumulation is generally uniform.

A fen located in the main channel or along the banks of permanent or permanent streams. This fen is affected by the water of the stream at normal and flood stages.

PMDEPOI = Mode of deposition or origin of first (upper) parent material.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AN</td>
<td>Anthropogenic</td>
<td>Materials modified by human activity so that their physical properties have been drastically altered; they include borrow pits, gravel pits, and road beds. Bogs consist of unspecified organic materials associated with an ombrotrophic environment because the slightly elevated nature of the bog dissociates it from nutrient-rich groundwater or surrounding mineral soils; near the surface, materials are usually not or very little decomposed (fibric), yellowish to pale brown, and loose and spongy in consistency, with entire sphagnum plants readily identifiable; these materials extremely acid, with low bulk density and high fiber content; at depths they become darker, compacted, and somewhat layered; bogs are associated with slopes or depressions on topography</td>
</tr>
</tbody>
</table>
F Fluvial
with a water table at or near the surface
in the spring and slightly below it during
the rest of the year; they are usually
covered with sphagnum mosses, but sedges
may also grow on them; bogs may be treed
or treeless, and many are characterized by
a layer of ericaceous shrubs.

FN Fen
Sediment generally consisting of silt
and clay with a minor fraction of sand and
gravel; gravels are typically rounded;
aluvial sediments are commonly moderately
to well sorted and display stratification.
Fen consists of unspecified organic
materials formed in a minerotrophic
environment because of the close
association of the material with mineral-
rich waters; it is usually moderately well
decomposed, dark brown to black,
with fine- to medium-sized fibers;
decomposition commonly becomes greater at
lower depths; the materials are covered
with a dominant component of sedges or
brown mosses, but grasses, reeds, sphagnum
mosses, shrubs, and trees may be
associated.

GF Glaciofluvial
Material moved by glaciers and
subsequently sorted and deposited by
streams flowing from the melting ice;
deposits are stratified and may occur in
the form of outwash plains, deltas, kames,
eskers, and kame terraces.

GL Glaciolacustrine
Sediment generally consisting of
either stratified fine sand, silt, and
clay deposited on the glacial lake bed or
moderately well sorted and stratified sand
and coarser materials that are beach and
other near-shore sediments transported and
deposited by wave action; these materials
either have settled from suspension in
bodies of standing freshwater or have
accumulated at their margins through wave
action.

O Organic
A layered sequence of more than three
types of organic undifferentiated material
(>30% organic matter by weight).

R Residual
Unconsolidated, weathered, or partly
weathered soil mineral materials that
accumulate by disintegration of bedrock
in place.

T Till (Morainal)
Sediment generally consisting of well-
compacted material that is nonstratified
and contains a heterogeneous mixture of
sand, silt, and clay particle sizes and
course fragments in a mixture that has
been transported beneath, beside, on, within, or in front of a glacier and not modified by any intermediate agent.
A consolidated bedrock layer that is too hard to break with the hands (>3 on Mohs' scale) or to dig with a spade when moist.

9. **TXTURE1 = Texture of first (upper) parent material.**

Soil texture indicates the relative proportions of the various soil separates in a soil. Soil separates are mineral particles, <2.0 mm in equivalent diameter, ranging between specified size limits:

<table>
<thead>
<tr>
<th>Soil separate</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very coarse sand</td>
<td>2.0-1.0</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>1.0-0.50</td>
</tr>
<tr>
<td>Medium sand</td>
<td>0.50-0.25</td>
</tr>
<tr>
<td>Fine sand</td>
<td>0.25-0.10</td>
</tr>
<tr>
<td>Very fine sand</td>
<td>0.10-0.05</td>
</tr>
<tr>
<td>Silt</td>
<td>0.05-0.002</td>
</tr>
<tr>
<td>Clay</td>
<td>&lt;0.002</td>
</tr>
</tbody>
</table>

Coarse fragments are rock or mineral fragments >2.0 mm in diameter:

<table>
<thead>
<tr>
<th>Coarse fragment</th>
<th>Diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>0.2-7.5</td>
</tr>
<tr>
<td>Cobble</td>
<td>7.5-25.0</td>
</tr>
</tbody>
</table>

Sands. Sand is a soil material that contains 85% or more sand; the percentage of silt plus 1.5 times the percentage of clay does not exceed 15.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCS</td>
<td>Very Coarse Sand</td>
<td>25% or more very coarse sand, and less than 50% any other one grade of sand. 25% or more very coarse and coarse sand, and less than 50% any other grade of sand.</td>
</tr>
<tr>
<td>CS</td>
<td>Coarse Sand</td>
<td>25% or more very coarse, coarse, and medium sand (but less than 25% very coarse and coarse sand), and less than 50% of either fine or very fine sand.</td>
</tr>
<tr>
<td>S</td>
<td>Sand</td>
<td>50% or more fine sand, or less than 25% very coarse, coarse, and medium sand and less than 50% very fine sand.</td>
</tr>
<tr>
<td>FS</td>
<td>Fine Sand</td>
<td>50% or more very fine sand.</td>
</tr>
<tr>
<td>VFS</td>
<td>Very Fine Sand</td>
<td>50% or more very fine sand.</td>
</tr>
</tbody>
</table>

Loamy Sands. Loamy sand is a soil material that contains at the upper limit 85-90% sand, and the percentage of silt plus 1.5 times the percentage of clay does not less than 15; at the lower limit it contains not less than 70-85% sand, and the percentage of silt plus twice the percentage of clay does not exceed 30.
<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCS</td>
<td>Loamy Coarse Sand</td>
<td>25% or more very coarse and coarse sand, and less than 50% any other one grade of sand.</td>
</tr>
<tr>
<td>LS</td>
<td>Loamy Sand</td>
<td>25% or more very coarse, coarse, and medium sand (but less than 25% very coarse and coarse sand), and less than 50% fine or very fine sand.</td>
</tr>
<tr>
<td>LFS</td>
<td>Loamy Fine Sand</td>
<td>50% or more fine sand, or less than 50% very fine sand and less than 25% very coarse, coarse, and medium sand.</td>
</tr>
<tr>
<td>LVFS</td>
<td>Loamy Very Fine Sand</td>
<td>50% or more very fine sand.</td>
</tr>
</tbody>
</table>

Sandy Loams. Sandy loam is a soil material that contains either 20% clay or less, with the percentage of silt plus twice the percentage of clay exceeding 30, and 52% or more sand; or less than 7% clay, less than 50% silt, and 43-52% sand.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSL</td>
<td>Coarse Sandy Loam</td>
<td>25% or more very coarse and coarse sand and less than 50% any other one grade of sand.</td>
</tr>
<tr>
<td>SL</td>
<td>Sandy Loam</td>
<td>30% or more very coarse, coarse, and medium sand (but less than 25% very coarse and coarse sand), and less than 30% of either very fine or fine sand.</td>
</tr>
<tr>
<td>FSL</td>
<td>Fine Sandy Loam</td>
<td>30% or more fine sand and less than 30% very fine sand; or between 15-30% very fine sand; or between 15-30% very coarse, coarse, and medium sand; or more than 40% fine and very fine sand, at least half of which is fine sand, and less than 15% very coarse, coarse and medium sand.</td>
</tr>
<tr>
<td>VFSL</td>
<td>Very Fine Sandy Loam</td>
<td>30% or more very fine sand, or more than 40% fine and very fine sand, at least half of which is very fine sand, and less than 15% very coarse, coarse, and medium sand.</td>
</tr>
</tbody>
</table>

Textures finer than sandy loams:

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Loam</td>
<td>7-27% clay, 28-50% silt, and less than 52% sand.</td>
</tr>
<tr>
<td>SIL</td>
<td>Silt Loam</td>
<td>50% or more silt and 12-27% clay, or 50-80% silt and less than 12% clay.</td>
</tr>
<tr>
<td>SI</td>
<td>Silt</td>
<td>80% or more silt and less than 12% clay.</td>
</tr>
<tr>
<td>SCL</td>
<td>Sandy Clay Loam</td>
<td>20-35% clay, less than 28% silt, and 45% or more sand.</td>
</tr>
<tr>
<td>CL</td>
<td>Clay Loam</td>
<td>27-40% clay and 20-45% sand.</td>
</tr>
<tr>
<td>Code</td>
<td>Class</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>GR</td>
<td>Gravelly</td>
<td>15-35% gravel by volume</td>
</tr>
<tr>
<td>VG</td>
<td>Very gravelly</td>
<td>35-60% gravel by volume</td>
</tr>
<tr>
<td>EG</td>
<td>Extremely gravelly</td>
<td>&gt;60% gravel by volume</td>
</tr>
<tr>
<td>MU</td>
<td>Mucky</td>
<td>9-17% organic carbon</td>
</tr>
<tr>
<td>GY</td>
<td>Gritty</td>
<td>Sharp-edged particles present</td>
</tr>
<tr>
<td>AY</td>
<td>Ashy</td>
<td>Quantities of volcanic or organic ash present</td>
</tr>
<tr>
<td>WY</td>
<td>Woody</td>
<td>Quantities of woody fragments present</td>
</tr>
</tbody>
</table>

10. **TEXTMOD1** = Texture modifier of first (upper) parent material.

11. **PMDEPO2** = Mode of deposition or origin of second (middle) parent material.

12. **TEXTURE2** = Texture of second (middle) parent material.

13. **TXTMOD2** = Texture modifier of second (middle) parent material.

14. **PMDEPO3** = Mode of deposition or origin of third (lower) parent material.

15. **TEXTURE3** = Texture of third (lower) parent material.

16. **TXTMOD3** = Texture modifier of third (lower) parent material.

17. **COFRAGS** = Coarse fragment content in control section of mineral soils.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt;1% by volume</td>
<td>Rounded, subrounded, flat, angular or irregular rock fragment from 2 mm to 60 cm or more in size.</td>
</tr>
<tr>
<td>B</td>
<td>1-15%</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>16-35%</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>36-60%</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>&gt;60%</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Not applicable</td>
<td></td>
</tr>
</tbody>
</table>
18. **SLOPE** = Slope gradient class.

The slope is generally the average or common slope of the unit, but in the case of complex topography, the steepest slope class is listed.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-2%</td>
</tr>
<tr>
<td>4</td>
<td>3-5%</td>
</tr>
<tr>
<td>8</td>
<td>6-9%</td>
</tr>
<tr>
<td>13</td>
<td>10-15%</td>
</tr>
<tr>
<td>25</td>
<td>16-30%</td>
</tr>
<tr>
<td>45</td>
<td>31-60%</td>
</tr>
</tbody>
</table>

19. **DRAINAGE** = Drainage class.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR</td>
<td>Very rapid</td>
<td>Water is removed from the soil very rapidly in relation to supply; excess water flows downward very rapidly if underlying material is pervious; subsurface flow may be very rapid during heavy rainfall provided the gradient is steep; source of water is precipitation.</td>
</tr>
<tr>
<td>R</td>
<td>Rapid</td>
<td>Water is removed from the soil rapidly in relation to supply; excess water flows downward if underlying material is pervious; subsurface flow may occur on steep gradients during heavy rainfall; source of water is precipitation.</td>
</tr>
<tr>
<td>W</td>
<td>Well</td>
<td>Water is removed from the soil readily but not rapidly; excess water flows downward readily into underlying pervious material or laterally as subsurface flow; these soils commonly retain optimum amounts of moisture for plant growth after rains or addition of irrigation water.</td>
</tr>
<tr>
<td>MW</td>
<td>Moderately well</td>
<td>Water is removed from the soil somewhat slowly in relation to supply; excess water is removed somewhat slowly because of low perviousness, shallow water table, lack of gradient, or some combination of these; precipitation is the dominant source of water in medium to fine textured soils; precipitation and significant additions by subsurface flow are necessary in coarse-textured soils.</td>
</tr>
</tbody>
</table>
| I    | Imperfect      | Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season; excess water
moves slowly downward if precipitation is the major supply; if subsurface water or groundwater, or both, is the main source, the flow rate may vary, but the soil remains wet for a significant part of the growing season.

Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen; excess water is evident in the soil for much of the time; subsurface flow or groundwater flow, or both, in addition to precipitation, are the main sources of water; there may also be a perched water table.

Water is removed from the soil so slowly that the water table remains at or near the surface for most of the time the soil is not frozen; groundwater flow and subsurface flow are the major sources of water; precipitation is less important except where there is a perched water table.

# Not applicable

20. DEPTHWT = Average depth to water table.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20 cm</td>
<td>10</td>
<td>Most shallow water table during growing season.</td>
</tr>
<tr>
<td>20-75 cm</td>
<td>50</td>
<td>With perennially frozen subsoil.</td>
</tr>
<tr>
<td>75-150 cm</td>
<td>125</td>
<td>(Water, ice, rock.)</td>
</tr>
<tr>
<td>&gt;150 cm</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>0-100 cm</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td># Not applicable</td>
<td>#</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

21. PFDISTR = Permafrost distribution or occurrence

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Very sporadic</td>
<td>Sparse patches of permafrost are associated with the component.</td>
</tr>
<tr>
<td>S</td>
<td>Sporadic</td>
<td>Isolated patches or islands of permafrost occur within the component.</td>
</tr>
<tr>
<td>D</td>
<td>Discontinuous</td>
<td>Widespread permafrost occurs within the component.</td>
</tr>
<tr>
<td>C</td>
<td>Continuous</td>
<td>Permafrost underlies all or almost all of the component.</td>
</tr>
<tr>
<td>#</td>
<td>Not applicable</td>
<td></td>
</tr>
</tbody>
</table>
22. \( \text{DPTHACT} = \text{Depth of active layer (average)}. \)

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>35–75 cm</td>
<td>Depth of top layer of ground subject to annual thawing and freezing in areas underlain by permafrost</td>
</tr>
<tr>
<td>100</td>
<td>&gt;75 cm</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

23. \( \text{ICECTNT} = \text{Ice content of permanently frozen layer}. \)

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Low</td>
<td>Ice content (volume) less than available pore space in non frozen soil.</td>
</tr>
<tr>
<td>M</td>
<td>Medium</td>
<td>No excess ice; ice content (volume) equal to pore space of non frozen soil.</td>
</tr>
<tr>
<td>H</td>
<td>High</td>
<td>Excess ice: ice content greater than pore space in non frozen soil; ice usually in the form of lenses, vein ice, or massive ground ice.</td>
</tr>
</tbody>
</table>

24. \( \text{DPTHLFH} = \text{Thickness of humus layer (LFH)}. \)

The thickness of the humus layer is estimated, and based on observations in the field. However, the frequency of forest fires in the area may reduce deep LFH layers to zero from one year to the next.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;5 cm</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5–10 cm</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>11–20 cm</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>21–40 cm</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>&gt;40 cm</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Not applicable (e.g., borrow pit, organic deposits)</td>
<td></td>
</tr>
</tbody>
</table>

25. \( \text{DPTHORG} = \text{Average thickness of peat deposit}. \)

Peat consist of organic material that accumulated under very wet or saturated conditions.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;0.2 m</td>
<td>Peat development has just started (paludification), or depth of peat layer has been reduced by fire.</td>
</tr>
<tr>
<td>1</td>
<td>0.2–0.6 m</td>
<td>Peat depth generally less than 40 cm if peat depth is rather uniform; or peat depth is on average about 40 cm but varies strongly over short distances because of sphagnum hummock formation.</td>
</tr>
<tr>
<td>2</td>
<td>0.6–1.6 m</td>
<td>Shallow peat (fens and bogs).</td>
</tr>
</tbody>
</table>
3  1.6-3.0 m  Deep peat.
4  >3.0 m    Very deep peat.

26. **SOILDEV** = Soil development (soil classification).

The dominant soil development associated with the polygon component. Other kinds of soil development are usually present, but only as inclusions.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDYB</td>
<td>Eluviated Dystric Brunisol</td>
</tr>
<tr>
<td>GLEYB</td>
<td>Gleyed Eluviated Dystric Brunisol</td>
</tr>
<tr>
<td>EEB</td>
<td>Eluviated Eutric Brunisol</td>
</tr>
<tr>
<td>GLEEYB</td>
<td>Gleyed Eluviated Eutric Brunisol</td>
</tr>
<tr>
<td>OHG</td>
<td>Orthic Humic Gleysol</td>
</tr>
<tr>
<td>RHG</td>
<td>Rego Humic Gleysol</td>
</tr>
<tr>
<td>OG</td>
<td>Orthic Gleysol</td>
</tr>
<tr>
<td>FEG</td>
<td>Ferric Gleysol</td>
</tr>
<tr>
<td>OLG</td>
<td>Orthic Luvic Gleysol</td>
</tr>
<tr>
<td>HULG</td>
<td>Humic Luvic Gleysol</td>
</tr>
<tr>
<td>OGL</td>
<td>Orthic Gray Luvisol</td>
</tr>
<tr>
<td>DGL</td>
<td>Dark Gray Luvisol</td>
</tr>
<tr>
<td>GLGL</td>
<td>Gleyed Gray Luvisol</td>
</tr>
<tr>
<td>GLDGL</td>
<td>Gleyed Dark Gray Luvisol</td>
</tr>
<tr>
<td>TYF</td>
<td>Typic Fibrisol</td>
</tr>
<tr>
<td>MEF</td>
<td>Mesic Fibrisol</td>
</tr>
<tr>
<td>TF</td>
<td>Terric Fibrisol</td>
</tr>
<tr>
<td>TMEF</td>
<td>Terric Mesic Fibrisol</td>
</tr>
<tr>
<td>HYF</td>
<td>Hydric Fibrisol</td>
</tr>
<tr>
<td>TYM</td>
<td>Typic Mesisol</td>
</tr>
<tr>
<td>FIM</td>
<td>Fibric Mesisol</td>
</tr>
<tr>
<td>TM</td>
<td>Terric Mesisol</td>
</tr>
<tr>
<td>TFIM</td>
<td>Terric Fibric Mesisol</td>
</tr>
<tr>
<td>THUM</td>
<td>Terric Mesic Humisol</td>
</tr>
<tr>
<td>TH</td>
<td>Terric Humisol</td>
</tr>
<tr>
<td>TFM</td>
<td>Terric Fibric Humisol</td>
</tr>
<tr>
<td>THM</td>
<td>Terric Mesic Humisol</td>
</tr>
<tr>
<td>TMH</td>
<td>Terric Mesic Humisol</td>
</tr>
<tr>
<td>CUHR</td>
<td>Cumulic Humic Regosol</td>
</tr>
<tr>
<td>OSC</td>
<td>Orthic Static Cryosol</td>
</tr>
<tr>
<td>RSC</td>
<td>Regosolic Static Cryosol</td>
</tr>
<tr>
<td>OTC</td>
<td>Orthic Turbic Cryosol</td>
</tr>
<tr>
<td>RTC</td>
<td>Regosolic Turbic Cryosol</td>
</tr>
<tr>
<td>FIOC</td>
<td>Fibric Organic Cryosol</td>
</tr>
<tr>
<td>MEOC</td>
<td>Mesic Organic Cryosol</td>
</tr>
<tr>
<td>HUOC</td>
<td>Humic Organic Cryosol</td>
</tr>
</tbody>
</table>
This designation has been used to identify Luvisolic soils with permafrost within the control section. These soils are at present not recognized in the Canadian System of Soil Classification.

A soil that has a lithic contact within the control section.

A soil that has a peaty layer 15-40 cm thick.

A soil that is relatively deep.

A soil with a relatively deep duff layer.

A soil that is relatively shallow.

A soil that is very deep.

A soil that is very shallow.

A soil that varies in a number of properties from the model (series concept).

A soil that varies in one or more specific properties from the series concept.
30. **SOILTP2** = Subdominant soil type associated with polygon component.

The subdominant soil type listed represents the soils that occupy <50% of the component. The soil type may be a soil series, which is a soil type defined within narrow limits, or a group of soils that vary to some extent in texture, depth of profile, etc. The soil type used to identify organic landscape components is the soil that best represents the group or complex of soils associated with that particular landscape component. The organic soil type usually represents related, but sometimes quite different, soils. These variations may include peat depth, presence or absence of certain peat layers, variation in peat decomposition, etc.

31. **SOILPH2** = Soil phase or variant associated with subdominant soil type.

The soil phase or variant is used to identify more specifically the subdominant soil type component (see no. 29 for codes).

**7.3.3 Unit of Measurement**

See Section 7.3.2.

**7.3.5 Data Range**

Image files:

Each pixel in the image files contains the polygon number value. This value is matched to the polygon number listed in the corresponding ASCII soils table file. The values for the polygon number apply to that polygon.

**7.4 Sample Data Record**

Sample data records from the binary images are not appropriate here. The following four sample records illustrate how the data set is formatted in the ASCII soils table files. Because the records are so long, they are presented here in multiple lines. The first record lists the column headings. The tables can be easily loaded into most spreadsheet programs by reading the data as comma-separated values (CSV). Any data columns that contain commas within the data are enclosed by double quotes (").

```
POLYNUM,GRIDLOC,COMPONT,NUMBER,PERCENT,KINDMAT,LANDFRM,PMDEPO1,TXTURE1,TXTMOD1,PMDEPO2,TXTURE2,TXTMOD2,PMDEPO3,TXTURE3,TXTMOD3,COFRAGS,SLOPE,DRAINAGE,DEPTHWT,PFIDSTR,DPTHACT,ICECTNT,DPTHLFH,DPTHORG,SOILDEV,VARIANT,SOILTP1,SOILPH1,SOILTP2,SOILPH2
1,G11,"D,I","D1,I1","D1=85,I1=15",SO,ui,GL,FS,GR,GF,FSL,GR,,-,-,-,4,I,200,*,*,L,1,0,EEB,p,EEB,d,MED,d2,G10,"D,S","D1,S1","D1=55,S1=45",OR,1Bv,B,M,WY,,-,-,-,-,-,-,-,1,0,10,*,*,L,0,2,FIM,*,FIM,d,MED,d
3,H10,"D,I","D1,D2,I1","D1=60,D2=30,I1=10",SO,1,B,M,WY,T,CS,GR,,-,-,-,-,1,1,200,*,*,L,2,1,OHG,p,OHG,d,OHG,d
```
8. Data Organization

8.1 Data Granularity

The smallest unit of data for this data set is the entire data set, with the soil image and soil table bundled together. The image file contains binary 8-bit (1-byte) values. The ASCII soils table files contain text records in which the soil attribute values are comma-delimited.

8.2 Data Format(s)

8.2.1 Uncompressed Data Files

The binary raster files of the tower sites are stored as 8-bit values. The soils table files that indicate the soil parameters for the polygons in each map are stored in ASCII text files. The overall content of this product is:

| File 1 | ASCII header file describing the product |
| File 2 | SSA-OBS Tower Area Binary Soils Map |
| File 3 | SSA-OJP Tower Area Binary Soils Map |
| File 4 | SSA-Fen Tower Area Binary Soil Map |
| File 5 | SSA-OA Tower Area Binary Soils Map |
| File 6 | SSA-YJP Tower Area Binary Soils Map |
| File 7 | SSA-OBS Soils Polygon Data Table (ASCII) |
| File 8 | SSA-OJP Soils Polygon Data Table (ASCII) |
| File 9 | SSA-Fen Soils Polygon Data Table (ASCII) |
| File 10 | SSA-OA Soils Polygon Data Table (ASCII) |
| File 11 | SSA-YJP Soils Polygon Data Table (ASCII) |

The files have the following characteristics:

<table>
<thead>
<tr>
<th>File #</th>
<th>Record Size (Bytes)</th>
<th>Bytes/ Pixel</th>
<th># Records</th>
</tr>
</thead>
<tbody>
<tr>
<td>File 1</td>
<td>80</td>
<td>N/A</td>
<td>15</td>
</tr>
<tr>
<td>File 2</td>
<td>175</td>
<td>1</td>
<td>243</td>
</tr>
<tr>
<td>File 3</td>
<td>130</td>
<td>1</td>
<td>130</td>
</tr>
<tr>
<td>File 4</td>
<td>130</td>
<td>1</td>
<td>130</td>
</tr>
<tr>
<td>File 5</td>
<td>130</td>
<td>1</td>
<td>130</td>
</tr>
<tr>
<td>File 6</td>
<td>130</td>
<td>1</td>
<td>130</td>
</tr>
<tr>
<td>File 7</td>
<td>250</td>
<td>N/A</td>
<td>26</td>
</tr>
<tr>
<td>File 8</td>
<td>250</td>
<td>N/A</td>
<td>7</td>
</tr>
<tr>
<td>File 9</td>
<td>250</td>
<td>N/A</td>
<td>31</td>
</tr>
<tr>
<td>File 10</td>
<td>250</td>
<td>N/A</td>
<td>19</td>
</tr>
<tr>
<td>File 11</td>
<td>250</td>
<td>N/A</td>
<td>7</td>
</tr>
</tbody>
</table>

8.2.2 Compressed CD-ROM Files

On the BOREAS CD-ROMs, files 1 and 7-11 listed above are stored as ASCII text files; however, files 2-6 have been compressed with the Gzip compression program (file name *.gz). These data have been compressed using gzip version 1.2.4 and the high compression (-9) option (Copyright (C) 1992-1993 Jean-loup Gailly). Gzip (GNU zip) uses the Lempel-Ziv algorithm (Welch, 1994) used in the zip and PKZIP programs. The compressed files may be uncompressed using gzip (-d option) or gunzip. Gzip is available from many Web sites (for example, ftp site prep.ai.mit.edu/pub/gnu/gzip-*.*) for a variety of operating systems in both executable and source code form. Versions of the decompression software for various systems are included on the CD-ROMs.
9. Data Manipulations

9.1 Formulae
None.

9.1.1 Derivation Techniques and Algorithms
No detailed information about the measurement techniques was provided, except for those that are listed in the BOREAS TE-01 Soils Lab Data. The reader is also referred to the detailed report submitted by Dr. Veldhuis for details on the derivation of the Northern Study Area (NSA) Soils maps. This report may provide details about what are believed to be standard techniques for determining soil properties. It is believed that similar techniques were used to map the SSA soils.

9.2 Data Processing Sequence
The data were received from the TE-01 science team as DLG files, which were read into ARC/INFO and gridded to 10-meter cell sizes. The gridded data were then written out as binary raster files.

9.2.1 Processing Steps
BOREAS Information System (BORIS) staff processed the data by:
- Reading in DLG files to ARC/INFO coverages.
- Determining whether unique polygon numbers exist within the map for each tower and if not, modifying them so that they are unique and match the corresponding data in the soil parameter table.
- Converting Universal Transverse Mercator (UTM) coverages to AEAC projection coverages.
- Gridding AEAC coverages into ARC/INFO GRID format.
- Writing out gridded data from ARC/INFO GRID to flat raster files.
- Writing out raster files, soil attribute tables, and documentation to tape.
- Copying the ASCII and compressing the binary files for release on CD-ROM.

9.2.2 Processing Changes
None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments
Unknown.

9.3.2 Calculated Variables
None.

9.4 Graphs and Plots
None.

10. Errors

10.1 Sources of Error
Errors could result from the change in format from vector to raster. However, the raster images were thoroughly checked and compared to the original vector data to avoid such problems. The vector data set was an original mapping using data collected directly from the field along with aerial photos. Errors could arise from a typographical error in the field notes.

10.2 Quality Assessment
10.2.1 Data Validation by Source
Any questions regarding how the soil properties were derived should be directed to Dr. Darwin Anderson.

10.2.2 Confidence Level/Accuracy Judgment
Unknown.

10.2.3 Measurement Error for Parameters
Unknown.

10.2.4 Additional Quality Assessments
None.

10.2.5 Data Verification by Data Center
BORIS personnel viewed and compared the images with the original vector data to identify any possible discrepancies. Nothing unusual was noted in the review.

11. Notes

11.1 Limitations of the Data
Unknown.

11.2 Known Problems with the Data
None.

11.3 Usage Guidance
Before uncompressing the Gzip files on CD-ROM, be sure that you have enough disk space to hold the uncompressed data files. Then use the appropriate decompression program provided on the CD-ROM for your specific system.

11.4 Any Other Relevant Information about the Study
For more information on this data set, please consult Dr. Darwin Anderson.

12. Application of the Data Set
This data set was created for BOREAS investigators who needed soils data in the vicinity of the flux towers.

13. Future Modifications and Plans
None.

14. Software

14.1 Software Description
The original vector data were digitized with a package called PAMAP at the University of Saskatchewan. ARC/INFO Geographic Information system (GIS) software was used by BORIS staff to grid this data set from its original vector form. The ARC/INFO software is a proprietary package developed and distributed by Environmental Systems Research Institute, Inc. (ESRI). Gzip (GNU zip) uses the Lempel-Ziv algorithm (Welch, 1994) used in the zip and PKZIP commands.
14.2 Software Access
The status of PAMAP is unknown. It is believed to be proprietary software. ARC/INFO is proprietary software with copyright protection. Contact ESRI for details:

Environmental Systems Research Institute, Inc. (ESRI)
380 New York St.
Redlands, CA 92373-8100

Gzip is available from many Web sites across the Internet (for example, ftp site prep.ai.mit.edu/pub/gnu/gzip-*.*) for a variety of operating systems in both executable and source code form. Versions of the decompression software for various systems are included on the CD-ROMs.

15. Data Access

The TE-01 soils data over the SSA tower sites in raster format are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information
For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification
Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics

15.3 Procedures for Obtaining Data
Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans
The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products
These data can be available on 1600 or 6250 Bytes Per Inch (BPI) 8 mm, Digital Archive Tape (DAT), or 9-track tapes.
16.2 Film Products
None.

16.3 Other Products
These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation


17.2 Journal Articles and Study Reports


17.3 Archive/DBMS Usage Documentation
None.
18. Glossary of Terms

None.

19. List of Acronyms

AEAC - Albers Equal Area Conic
ASCII - American Standard Code for Information Interchange
BOREAL - BOREal Ecosystem-Atmosphere Study
BORIS - BOREAS Information System
BPI - Bytes Per Inch
CD-ROM - Compact Disk - Read-Only-Memory
CSV - Comma-Separated Values
DAAC - Distributed Active Archive Center
DAT - Digital Archive Tape
DLG - Digital Line Graph
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
ESRI - Environmental Systems Research Institute, Inc.
GIS - Geographic Information System
GMT - Greenwich Mean Time
GPS - Global Positioning System
GSFC - Goddard Space Flight Center
MSA - Modeling Sub-Area
NAD27 - North American Datum of 1927
NAD83 - North American Datum of 1983
NASA - National Aeronautics and Space Administration
NSA - Northern Study Area
OA - Old Aspen
OBS - Old Black Spruce
OJP - Old Jack Pine
ORNL - Oak Ridge National Laboratory
PANP - Prince Albert National Park
SSA - Southern Study Area
TE - Terrestrial Ecology
URL - Uniform Resource Locator
UTM - Universal Transverse Mercator
WWW - World Wide Web
YJP - Young Jack Pine

20. Document Information

20.1 Document Revision Date
Written: 07-May-1997
Last Updated: 11-Feb-1999

20.2 Document Review Dates
BORIS Review: 05-Aug-1997
Science Review:
20.4 Citation

When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:

The BOREAS SSA soils data were compiled and processed by Dr. Darwin Anderson and BORIS staff. Their contributions to providing this data set are greatly appreciated.

If using data from the BOREAS CD-ROM series, also reference the data as:


Also, cite the BOREAS CD-ROM set as:

The BOREAS TE-1 team collected various data to characterize the soil-plant systems in the BOREAS SSA. This data set was gridded from vector layers of soil maps that were received from Dr. Darwin Anderson (TE-1), who did the original soil mapping in the field during 1994. The vector layers were gridded into raster files that cover approximately 1 square kilometer over each of the tower sites in the SSA.