NASA/TM—2000–209891, Vol. 125

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

Forrest G. Hall, Editor

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

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National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000

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

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

Darwin Anderson, David Knapp

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
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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
DRAINGE = Drainage class
DEPTHWT = Depth to water table, average
PFDISTR = 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 Mesisols 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).

SSA-OBS (175 pixels by 243 lines, 10-meter pixel size)

Point	BOREAS_X	BOREAS_Y	Longitude	Latitude
Northwest	384.140	350.350	105.12886W	54.00308N
Northeast	385.890	350.350	105.10224W	54.00175N
Southwest	384.140	347.920	105.13198W	53.98134N
Southeast	385.890	347.920	105.10538W	53.98002N

SSA-OJP (130 pixels by 130 lines, 10-meter pixel size)

Point	BOREAS_X	BOREAS_Y	Longitude	Latitude
Northwest	412.880	343.870	104.70085W	53.92262N
Northeast	414.180	343.870	104.68113W	53.92156N
Southwest	412.880	342.570	104.70264W	53.91099N
Southeast	414.180	342.570	104.68292W	53.90994N

SSA-Fen (130 pixels by 130 lines, 10-meter pixel size)

Point	BOREAS_X	BOREAS_Y	Longitude	Latitude
Northwest	418.870	331.670	104.62696W	53.80867N
Northeast	420.170	331.670	104.60729W	53.80760N
Southwest	418.870	330.370	104.62877W	53.79705N
Southeast	420.170	330.370	104.60910W	53.79598N

SSA-OA (130 pixels by 130 lines, 10-meter pixel size)

Point	BOREAS_X	BOREAS_Y	Longitude	Latitude
Northwest	316.580	304.130	106.20636W	53.63579N
Northeast	317.880	304.130	106.18673W	53.63499N
Southwest	316.580	302.830	106.20771W	53.62415N
Southeast	317.880	302.830	106.18809W	53.62334N

SSA-YJP (130 pixels by 130 lines, 10-meter pixel size)

Point	BOREAS_X	BOREAS_Y	Longitude	Latitude
Northwest	416.370	339.640	104.65377W	53.88196N
Northeast	417.670	339.640	104.63406W	53.88090N
Southwest	416.370	338.340	104.65557W	53.87034N
Southeast	417.670	338.340	104.63587W	53.86928N

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 is 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
TXTURE1
TXTMOD1
PMDEPO2
```

TXTURE2
TXTMOD2
PMDEPO3
TXTURE3
TXTMOD3
COFRAGS
SLOPE
DRAINGE
DEPTHWT
PFDISTR
DPTHACT
ICECTNT
DPTHLFH
DPTHORG
SOILDEV
VARIANT
SOILTP1
SOILPH1
SOILTP2
SOILPH2

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.

Code	Class	Description
D	Dominant	The D components combined cover >50% of the land area of a polygon.
S	Subdominant	The S components combined cover <50% of the land area of a polygon.
I	Inclusion	Each inclusion covers <15% of the polygon, but the combined area of inclusions may be 25%.
W	Water	Surface water in the form of lakes, pond,s or streams may cover between 5 and 100% of a polygon.

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.

Code	Class	Description
OR	Organic soil	Contains >30% organic matter by weight
R2	Hard rock, acidic	Granite
SO	Mineral soil	Dominant mineral particles, contains <30% organic matter by weight
WA	Water	Water

7. LANDFRM = Local surface form.

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

Code	Class	Description
b	blanket	Unconsolidated surficial materials >1 m thick.
d	dissected	Gullies or valleys dissect the component.
h	hummocky	A complex sequence of slopes extending from concavities of various sizes to knolls or short, discontinuous ridges.
i	inclined	A sloping, unidirectional surface with a generally constant slope not broken by marked irregularity or gullies.
k	knoll and kettle	A very chaotic sequence of knolls,

		ridges ,and kettles.
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.

Code	Class	Description
Ba	Palsa bog	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.
Bc	Collapse scar bog	A circular or oval-shaped wet depression in a perennially 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.
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.
Bv	Veneer bog	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.
Fb	Basin fen	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.
Fc	Collapse scar fen	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.
Fh	Horizontal fen	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.
Fs	Stream fen	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.

8. PMDEPO1 = Mode of deposition or origin of first (upper) parent material.

Code	Class	Description
AN	Anthropogenic	Materials modified by human activity so that their physical properties have been drastically altered; they include borrow pits, gravel pits, and road beds.
B	Bog	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

		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.
F	Fluvial	Sediment generally consisting of silt and clay with a minor fraction of sand and gravel; gravels are typically rounded; alluvial sediments are commonly moderately to well sorted and display stratification.
FN	Fen	Fen consistss 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 to 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 organicundifferentiated 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 coarse 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.
RK	Rock	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:

Soil separate	Diameter (mm)
Very coarse sand	2.0-1.0
Coarse sand	1.0-0.50
Medium sand	0.50-0.25
Fine sand	0.25-0.10
Very fine sand	0.10-0.05
Silt	0.05-0.002
Clay	<0.002

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

Coarse fragment	Diameter (cm)
Gravel	0.2-7.5
Cobble	7.5-25.0

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.

Code	Class	Description
VCS	Very Coarse Sand	25% or more very coarse sand, and less than 50% any other one grade of sand.
CS	Coarse Sand	25% or more very coarse and coarse sand, and less than 50% any other grade of sand.
S	Sand	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.
FS	Fine Sand	50% or more fine sand, or less than 25% very coarse, coarse, and medium sand and less than 50% very fine sand.
VFS	Very Fine Sand	50% or more very fine sand.

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 is 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.

Code	Class	Description
LCS	Loamy Coarse Sand	25% or more very coarse and coarse sand, and less than 50% any other one grade of sand.
LS	Loamy Sand	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.
LFS	Loamy Fine Sand	50% or more fine sand, or less than 50% very fine sand and less than 25% very coarse, coarse, and medium sand.
LVFS	Loamy Very Fine Sand	50% or more very fine sand.

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 then 7% clay, less than 50% silt, and 43-52% sand.

Code	Class	Description
CSL	Coarse Sandy Loam	25% or more very coarse and coarse sand and less than 50% any other one grade of sand.
SL	Sandy Loam	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.
FSL	Fine Sandy Loam	30% or more fine sand and less than 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.
VFSL	Very Fine Sandy Loam	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.

Textures finer than sandy loams:

Code	Class	Description
L	Loam	7-27% clay, 28-50% silt, and less than 52% sand.
SIL	Silt Loam	50% or more silt and 12-27% clay, or 50-80% silt and less than 12% clay.
SI	Silt	80% or more silt and less than 12% clay.
SCL	Sandy Clay Loam	20-35% clay, less than 28% silt, and 45% or more sand.
CL	Clay Loam	27-40% clay and 20-45% sand.

SICL	Silty Clay Loam	27-40% clay and less than 20% sand.
SC	Sandy Clay	35% or more clay and 45% or more sand.
SIC	Silty Clay	40% or more clay and 40% or more silt.
C	Clay	40% or more clay, less than 45% sand, and less than 40% silt.
HC	Heavy Clay	More than 60% clay.
O	Organic	Fiber content undifferentiated.
F	Fibric	40% or more rubbed fibre content by volume.
M	Mesic	Between 10% and 40% content by volume.
H	Humic	<10% rubbed fiber content by volume.

10. TXTMOD1 = Texture modifier of first (upper) parent material.

Code	Class	Description
GR	Gravelly	15-35% gravel by volume
VG	Very gravelly	35-60% gravel by volume
EG	Extremely gravelly	>60% gravel by volume
MU	Mucky	9-17% organic carbon
GY	Gritty	Sharp-edged particles present
AY	Ashy	Quantities of volcanic or organic ash present
WY	Woody	Quantities of woody fragments present (organic soils)

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

12. TXTURE2 = 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. TXTURE3 = 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.

Code	Class	Description
A	<1% by volume	Rounded, subrounded, flat, angular or irregular rock fragment from 2 mm to 60 cm or more in size.
B	1-15%	
C	16-35%	
D	36-60%	
E	>60%	
#	Not applicable	

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.

Code	Class
1	1-2%
4	3-5%
8	6-9%
13	10-15%
25	16-30%
45	31-60%

19. DRAINGE = Drainage class.

Code	Class	Description
VR	Very rapid	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.
R	Rapid	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.
W	Well	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.
MW	Moderately well	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.
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.
P	Poor	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.
VP	Very poor	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.

Code	Class	Description
10	0-20 cm	Most shallow water table during growing season.
50	20-75 cm	
125	75-150 cm	
200	>150 cm	
*	0-100 cm	With perennially frozen subsoil.
#	Not applicable	(Water, ice, rock.)

21. PFDISTR = Permafrost distribution or occurrence

Code	Class	Description
V	Very sporadic	Sparse patches of permafrost are associated with the component.
S	Sporadic	Isolated patches or islands of permafrost occur within the component.
D	Discontinuous	Widespread permafrost occurs within the component.
C	Continuous	Permafrost underlies all or almost all of the component.
#	Not applicable	

22. DPTHACT = Depth of active layer (average).

Code	Class	Description
50	35-75 cm	Depth of top layer of ground subject to annual thawing and freezing in areas underlain by permafrost
100	>75 cm.	
#	Not applicable	

23. ICECTNT = Ice content of permanently frozen laye.r

Code	Class	Description
L	Low	Ice content (volume) less than available pore space in non frozen soil.
M	Medium	No excess ice; ice content (volume) equal to pore space of non frozen soil.
H	High	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.

24. DPTHLFH = 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.

Code	Class
0	<5 cm
1	5-10 cm
2	11-20 cm
3	21-40 cm
4	>40 cm
#	Not applicable (e.g,. borrow pit, organic deposits)

25. DPTHORG = Average thickness of peat deposit.

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

Code	Class	Description
0	<0.2 m	Peat development has just started (paludification), or depth of peat layer has been reduced by fire.
1	0.2-0.6 m	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.
2	0.6-1.6 m	Shallow peat (fens and bogs).

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.

Code	Class
Brunisolic	
EDYB	Eluviated Dystric Brunisol
GLEDYB	Gleyed Eluviated Dystric Brunisol
EEB	Eluviated Eutric Brunisol
GLEEB	Gleyed Eluviated Eutric Brunisol
Gleysolic	
OHG	Orthic Humic Gleysol
RHG	Rego Humic Gleysol
OG	Orthic Gleysol
FEG	Ferric Gleysol
OLG	Orthic Luvic Gleysol
HULG	Humic Luvic Gleysol
Luvisolic	
OGL	Orthic Gray Luvisol
DGL	Dark Gray Luvisol
GLGL	Gleyed Gray Luvisol
GLDGL	Gleyed Dark Gray Luvisol
Organic	
TYF	Typic Fibrisol
MEF	Mesic Fibrisol
TF	Terric Fibrisol
TMEF	Terric Mesic Fibrisol
HYF	Hydric Fibrisol
TYM	Typic Mesisol
FIM	Fibric Mesisol
TM	Terric Mesisol
TFIM	Terric Fibric Mesisol
THUM	Terric Mesic Humisol
TH	Terric Humisol
TFIH	Terric Fibric Humisol
TMEH	Terric Mesic Humisol
CUHR	Cumulic Humic Regosol
Cryosolic	
OSC	Orthic Static Cryosol
RSC	Regosolic Static Cryosol
OTC	Orthic Turbic Cryosol
RTC	Regosolic Turbic Cryosol
FIOC	Fibric Organic Cryosol
MEOC	Mesic Organic Cryosol
HUOC	Humic Organic Cryosol

TFIOC	Terric Fibric Organic Cryosol
TMEOC	Terric Mesic Organic Cryosol
THUOC	Terric Humic Organic Cryosol

27. VARIANT = Classification variant or phase.

Code	Class	Description
c	Cryic	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.
l	Lithic	A soil that has a lithic contact within the control section.
p	Peaty	A soil that has a peaty layer 15-40 cm thick.
#	Not applicable	

28. SOILTP1 = Dominant soil type associated with polygon component.

The dominant 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.

29. SOILPH1 = Soil phase or variant associated with dominant soil type.

The soil phase or variant is used to identify more specifically the dominant soil type. These soils vary to some degree from the model because of differences in parent material (stratification, texture), depth of the LFH layer, peaty surface, coarse fragment content, etc.

Code	Class	Description
d	Deep	A soil that is relatively deep.
h	Humus	A soil with a relatively deep duff layer.
s	Shallow	A soil that is relatively shallow.
v	Very deep	A soil that is very deep.
w	Very shallow	A soil that is very shallow.
x	Complex	A soil that varies in a number of properties from the model (series concept).
1,2,3	Variant number	A soil that varies in one or more specific properties from the series concept.
#	Not applicable	

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,
PFDISTR,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,MEF,d2,G10,"D,S","D1,S1","D1=55,S1=45",OR,lBv,B,M,WY,-,-,-,-,-,-,
-,1,VP,10,#,#,L,0,2,FIM,#,FIM,d,MEF,d
3,H10,"D,I","D1,D2,I1","D1=60,D2=30,I1=10",SO,l,B,M,WY,T,CS,GR,-,-,-,-,1,I,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:

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

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 http://www-eosdis.ornl.gov/.

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

ARC/INFO User's Guide (Version 7). 1994. Redlands, CA.

Welch, T.A. 1984. A Technique for High Performance Data Compression. IEEE Computer, Vol. 17, No. 6, pp. 8-19.

17.2 Journal Articles and Study Reports

Brady,N.C. and R. R. Weil. 1996. The Nature And Properties Of Soils, 11th ed. Prentice Hall, Upper Saddle River, N.J. 740p.

Huang, W.Z. and Schoenau, J. J. 1996. Forms, amounts and distribution of carbon, nitroge, phosphorus, and sulphur in a boreal aspen forest soil. Can J. Soil Sci. 76: 373-385

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102 (D24): 28,731-28,770.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

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AEAC      - Albers Equal Area Conic
ASCII     - American Standard Code for Information Interchange
BOREAS    - 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
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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:

20.3 Document ID

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:

Dr. Darwin Anderson, "Soils of Tower Sites in the Southern Study Area." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

Also, cite the BOREAS CD-ROM set as:

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM. NASA, 2000.

20.5 Document Curator

20.6 Document URL

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
October 2000

3. REPORT TYPE AND DATES COVERED
Technical Memorandum

4. TITLE AND SUBTITLE
Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)
BOREAS TE-1 Soils Data over the SSA Tower Sites in Raster Format

5. FUNDING NUMBERS
923
RTOP: 923-462-33-01

6. AUTHOR(S)
Darwin Anderson and David E. Knapp
Forrest G. Hall, Editor

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES)
Goddard Space Flight Center
Greenbelt, Maryland 20771

8. PEFORMING ORGANIZATION REPORT NUMBER
2000-03136-0

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS (ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
TM—2000–209891
Vol. 125

11. SUPPLEMENTARY NOTES
D. Anderson: University of Saskatchewan, Saskatoon, SK, Canada;
D.E. Knapp: Raytheon ITSS, NASA Goddard Space Flight Center, Greenbelt, Maryland

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified–Unlimited
Subject Category: 43
Report available from the NASA Center for AeroSpace Information,
7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

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.

14. SUBJECT TERMS
BOREAS, terrestrial ecology, soil-plant systems.

15. NUMBER OF PAGES
30

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39.18
298-102