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

Forrest G. Hall and David E. Knapp, Editors

Volume 248

BOREAS TGB-12 Soil Carbon and Flux Data of NSA-MSA in Raster Format

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Jennifer W. Harden, U.S. Geological Survey, Menlo Park, California
Susan E. Trumbore, University of California, Irvine
Hugo Veldhuis, Agriculture and Agri-Food Canada

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

November 2000
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Summary

The BOREAS TGB-12 team made measurements of soil carbon inventories, carbon concentration in soil gases, and rates of soil respiration at several sites. This data set provides: (1) estimates of soil carbon stocks by horizon based on soil survey data and analyses of data from individual soil profiles; (2) estimates of soil carbon fluxes based on stocks, fire history, drainage, and soil carbon inputs and decomposition constants based on field work using radiocarbon analyses; (3) fire history data estimating age ranges of time since last fire; and (4) a raster image and an associated soils table file from which area-weighted maps of soil carbon and fluxes and fire history may be generated. This data set was created from raster files, soil polygon data files, and detailed lab analysis of soils data that were received from Dr. Hugo Veldhuis, who did the original mapping in the field during 1994. Also used were soils data from Susan Trumbore and Jennifer Harden (BOREAS TGB-12). The binary raster file covers a 733-km² area within the NSA-MSA.

Note that some of the files of this data set 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 TGB-12 Soil Carbon and Flux Data of NSA-MSA in Raster Format

1.2 Data Set Introduction
This data set contains soil properties and classification information, particularly soil carbon stocks and fluxes, time since last fire, and polygon area, over the BOREal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA)-Modeling Sub-Area (MSA), gridded to a 30-meter pixel resolution. The data were reprojected into the ellipsoidal version of the Albers Equal-Area Conic (AEAC) projection from the original map made by Dr. Hugo Veldhuis (Agriculture and Agri-Food Canada). The original map was then modified by Gloria Rapalee (The Woods Hole Research Center).

1.3 Objective/Purpose
These data are provided by the BOREAS Trace Gas and Biogeochemistry (TGB)-12 team and include pertinent map data in both hardcopy and digital form. This data set has been processed to provide a raster file that can be used for modeling or for comparison purposes. The purpose of this data set is to provide information about the fire history and spatial distribution of soil carbon stocks and fluxes over the NSA-MSA.

1.4 Summary of Parameters
This data set contains information about the spatial distribution of soil classes around the NSA-MSA along with soil class properties such as parent material, texture, slope class, and water table depth, as well as soil carbon stocks and fluxes, time since last fire, and polygon area. 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 file. The value of each pixel can link to the table described in Section 7 in order to extract these parameters.

1.5 Discussion
The spatial base of this data set is the vector layer by Dr. Hugo Veldhuis of Agriculture and Agri-Food Canada. Using aerial photography and field methods, he identified various soil polygons at a scale of 1:50,000 for the NSA-MSA (what Dr. Veldhuis calls the 'super site'). This data set was also produced from the detailed field soil data collected by Jennifer Harden and Susan Trumbore (TGB-12), plus data from related data sets listed in Section 1.6.

1.6 Related Data Sets
BOREAS AFM-12 1-km AVHRR Seasonal Land Cover Classification
BOREAS Forest Cover Data Layers of the NSA in Raster Format
BOREAS TE-13 Biometry Data
BOREAS TE-18 Landsat TM Maximum Likelihood Classification Image of the NSA
BOREAS TE-20 NSA Soil Lab Data
BOREAS TE-20 Soils Data over the NSA MSA and Tower Sites in Raster Format
BOREAS TE-20 Supplementary Soil & Site Information for NSA MSA and Tower Sites (Grab Bag)
BOREAS TGB-05 Fire History of Manitoba 1980 to 1991 in Raster Format
BOREAS TGB-12 Soil Carbon Data over the NSA
2. Investigator(s)

2.1 Investigator(s) Name and Title
Gloria Rapalee, Graduate Fellow, The Woods Hole Research Center
Eric A. Davidson, Associate Scientist, The Woods Hole Research Center
Jennifer W. Harden, Soil Scientist, United States Geological Survey
Susan E. Trumbore, Associate Professor, University of California, Irvine
Hugo Veldhuis, Senior Pedologist, Agriculture & Agri-Food Canada

2.2 Title of Investigation
Scaling Soil Carbon Stocks and Fluxes of Super Site Northern Study Area Thompson, Manitoba, Canada
Part of: Input, Accumulation, and Turnover of Carbon in Boreal Forest Soils: Integrating $^{14}$C Isotopic Analyses with Ecosystem Dynamics

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. The original soils map was then modified by Gloria Rapalee using a variety of available data to account for changes in vegetation due to a recent fire. These digital map data provide investigators with a continuous surface of soil parameters plus carbon stock and flux data that can further be used for modeling purposes.

4. Equipment

4.1 Sensor/Instrument Description
Please refer to the separate reports submitted by Drs. Veldhuis and Trumbore et al. regarding equipment used to perform the soils mapping. See Section 1.6.
In addition to field techniques, aerial photography flown in 1978 at 1:50,000 scale was used to map the soils of the NSA-MSA. 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. Hugo Veldhuis. The modified soil polygon file (this data set) was received in binary raster format.

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
TEXTURE1 = Texture of first (upper) parent material
TMDEPO1 = Texture modifier of first (upper) parent material
PMDEPO2 = Mode of deposition or origin of second (middle) parent material
TEXTURE2 = Texture of second (middle) parent material
TMDEPO2 = Texture modifier of second (middle) parent material
PMDEPO3 = Mode of deposition or origin of third (lower) parent material
TEXTURE3 = Texture of third (lower) parent material
TMDEPO3 = 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
PFIDISTR = Permafrost distribution or occurrence
DPTHACT = Depth of active layer (average)
ICECTNT = Ice content of permanently frozen layer
DPTHLTH = Thickness of humus layer (L,F,H)
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
TOTLAREA = Total area (hectares) of each soil polygon
COMPAREA = Area (hectares) of each polygon component
DR_CLASS = Drainage class (numerical code)
STND Age = Stand age; time since last fire
ST AGE GRP = Stand age; age ranges since last fire
C SURFACE = Area-weighted carbon stocks of surface layers, including moss
C DEEP = Area-weighted carbon stocks of deep soil horizons
C TOTAL = Area-weighted total carbon stock for entire profile
   (C_SURFACE + C_DEEP)
FL SURFACE = Area-weighted carbon fluxes of surface layers, including moss
FL_DEEP = Area-weighted carbon fluxes of deep soil horizons
FL_NET = Area-weighted carbon fluxes for entire profile
        \((FL\_SURFACE + FL\_DEEP)\)

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

A detailed report of the soils mapping effort, submitted by Dr. Veldhuis, is available. Part 2 of the report (Methodology) provides detailed information about data acquisition methods. Detailed documentation of Trumbore and Harden (TGB-12) field data and methods is also available. See Section 1.6.

6. Observations

6.1 Data Notes
The soils report by Dr. Veldhuis provides observations and descriptions of soils. Additional notes exist in files (not included here) submitted by Dr. Veldhuis. Site and field descriptions of Trumbore and Harden (TGB-12) sampling sites are also available. See Section 1.6.

6.2 Field Notes
Not applicable.
7. Data Description

7.1 Spatial Characteristics
The soil map in this data set covers a 733 km² area within the NSA-MSA. Details of spatial coverage and resolution are given in the following sections.

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

<table>
<thead>
<tr>
<th>Point</th>
<th>BOREAS_X</th>
<th>BOREAS_Y</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwest</td>
<td>759.33175</td>
<td>630.72800</td>
<td>-98.73055</td>
<td>56.06201</td>
</tr>
<tr>
<td>Northeast</td>
<td>801.93175</td>
<td>630.72800</td>
<td>-98.05756</td>
<td>55.99320</td>
</tr>
<tr>
<td>Southwest</td>
<td>759.33175</td>
<td>602.04800</td>
<td>-98.81086</td>
<td>55.80873</td>
</tr>
<tr>
<td>Southeast</td>
<td>801.93175</td>
<td>602.04800</td>
<td>-98.14207</td>
<td>55.74036</td>
</tr>
</tbody>
</table>

7.1.2 Spatial Coverage Map
The soil map in this data set covers a 733 km² area within the NSA-MSA.

7.1.3 Spatial Resolution
The pixel resolution is 30 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: W 111.000 degrees N 51.000 degrees
- Standard Parallels: N 52° 30' 00"
  - N 58° 30' 00"
- Units of Measure: kilometers

7.1.5 Grid Description
Each pixel represents an area of 30 by 30 meters in the AEAC projection described in Section 7.1.4.

7.2 Temporal Characteristics:

7.2.1 Temporal Coverage
Dr. Veldhuis collected field samples for mapping the MSA and the NSA tower sites in 1994. Air photos taken in 1978 at a scale of 1:50,000 were used for extending the field samples to map the NSA-MSA. Trumbore and Harden collected soil samples in 1993 and 1994. Several data sources (see Section 1.6) that postdate the 1978 air photos were used to generate the fire history data listed in the soils table file. The Landsat Thematic Mapper (TM) image and forest cover images date from 1988. Fire history images date from 1980 to 1991. Data from the AVHRR image are from 1992. Tree core data are from the 1993 biometry inventory of auxiliary sites. Also used was a set of fire history maps dating from 1937 to 1990 produced by Forestry Canada.

7.2.2 Temporal Coverage Map
Not applicable.
7.2.3 Temporal Resolution
Not applicable.

7.3 Data Characteristics
These data are in an image format in which the value of a pixel represents the polygon number from the original vector data, later modified by Gloria RapNee for this data set. This number can be related to a set of records in the ASCII soils table file. The soils table file contains parameters for the various polygons. Lakes are indicated with a polygon number of 237. Polygons with numbers greater than 237 are split from Dr. Veldhuis's original polygons.

7.3.1 Parameter/Variable
POLYNUM
GRIDLOC
COMPONENT
NUMBER
PERCENT
KINDMAT
LANDFRM
PMDEPO1
TEXTURE1
TXTMOD1
PMDEPO2
TEXTURE2
TXTMOD2
PMDEPO3
TEXTURE3
TXTMOD3
COFRAGS
SLOPE
DRAINAGE
DEPTHWT
PFDISTR
DPTHACT
ICECTNT
DPTHLFH
DPTHORG
SOILDEV
VARIANT
SOILTP1
SOILPH1
SOILTP2
SOILPH2
TOLAREA
COMPAREA
DR_CLASS
STND_AGE
ST_AGE_GRP
C_MOSS
C_DEEP
C_TOTAL
FL_MOSS
FL_DEEP
FL_TOTAL
7.3.2 Variable Description/Definition
Binary Raster Image File

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

ASCII soil table file:
1. POLYNUM = Number of the map polygon.
2. GRIDLOC = An alphanumeric grid to be used to find a particular polygon on the map.
3. COMPONENT = 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 the 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, the elements are all considered to belong to the dominant (D) or subdominant (S) group, but 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 to either the dominant or 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>Granite</td>
</tr>
<tr>
<td>SO</td>
<td>Mineral soil</td>
<td>Dominant mineral particles, contains &lt;30% organic matter by weight</td>
</tr>
<tr>
<td>WA</td>
<td>Water</td>
<td>Water</td>
</tr>
</tbody>
</table>

7. LANDFRM = Local surface form.

Mineral surface forms. Two classes may be combined. For example, "bh" is hummocky blanket; "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</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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</td>
</tr>
<tr>
<td></td>
<td></td>
<td>by marked irregularity or gullies.</td>
</tr>
<tr>
<td>k</td>
<td>knoll and kettle</td>
<td>A very chaotic sequence of knolls, ridges, and kettles.</td>
</tr>
<tr>
<td>l</td>
<td>level</td>
<td>A flat or very gently sloping unidirectional surface with a generally</td>
</tr>
<tr>
<td></td>
<td></td>
<td>constant slope not broken by marked elevations and depressions; slopes are</td>
</tr>
<tr>
<td></td>
<td></td>
<td>generally &lt;2%.</td>
</tr>
<tr>
<td>r</td>
<td>ridged</td>
<td>A long, narrow elevation of the surface, usually distinctly crested with</td>
</tr>
<tr>
<td></td>
<td></td>
<td>steep sides.</td>
</tr>
<tr>
<td>s</td>
<td>steep</td>
<td>Erosional slopes on both consolidated and unconsolidated materials.</td>
</tr>
<tr>
<td>u</td>
<td>undulating</td>
<td>A regular sequence of gentle slopes that extends from rounded and, in some</td>
</tr>
<tr>
<td></td>
<td></td>
<td>places, confined concavities to broad, rounded convexities; low local relief</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with slopes usually between 2-5%.</td>
</tr>
<tr>
<td>v</td>
<td>veneer</td>
<td>Unconsolidated surficial materials &lt;1 m thick. Veneers may be continuous or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>patchy.</td>
</tr>
<tr>
<td>w</td>
<td>beach, strandline</td>
<td>Low ridges with steeper slope on one</td>
</tr>
</tbody>
</table>
The classification of landforms is often the case of "best fit." Often 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 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.</td>
</tr>
<tr>
<td>Bt</td>
<td>Peat plateau bog</td>
<td>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.</td>
</tr>
<tr>
<td>Bv</td>
<td>Veneer bog</td>
<td>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.</td>
</tr>
<tr>
<td>Fb</td>
<td>Basin fen</td>
<td>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.</td>
</tr>
<tr>
<td>Fc</td>
<td>Collapse scar fen</td>
<td>A fen with circular or oval depressions, up to 100 m, occurring in larger fens, marking the subsidence of thawed permafrost peatlands. Dead trees,</td>
</tr>
</tbody>
</table>
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 semi-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.

<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, road beds.</td>
</tr>
<tr>
<td>B</td>
<td>Bog</td>
<td>Bogs consist of unspecified organic materials associated with an ombrotrophic environment because the slightly elevated nature of the bog dissociates it from nutrient-rich ground water or surrounding mineral soils; near the surface, materials are usually not or very little decomposed (fibric), yellowish to pale brown, loose and spongy in consistence, and entire sphagnum plants are readily identified; these materials are 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.</td>
</tr>
<tr>
<td>F</td>
<td>Fluvial</td>
<td>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.</td>
</tr>
<tr>
<td>FN</td>
<td>Fen</td>
<td>Fens consist 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,</td>
</tr>
</tbody>
</table>
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 fresh water 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 accumulates 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. **TEXTURE1 = 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.</td>
</tr>
<tr>
<td>CS</td>
<td>Coarse Sand</td>
<td>25% or more very coarse and coarse sand, and less than 50% any other grade of sand.</td>
</tr>
<tr>
<td>S</td>
<td>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>FS</td>
<td>Fine 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>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 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.

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

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

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<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 (organic soils)</td>
</tr>
</tbody>
</table>

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</td>
</tr>
</tbody>
</table>

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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 course 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 from 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.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0-20 cm</td>
<td>Most shallow water table during growing season.</td>
</tr>
<tr>
<td>50</td>
<td>20-75 cm</td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>75-150 cm</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>&gt;150 cm</td>
<td></td>
</tr>
<tr>
<td>*</td>
<td>0-100 cm</td>
<td>With perennally frozen subsoil.</td>
</tr>
<tr>
<td>#</td>
<td>Not applicable</td>
<td>(Water, ice, rock).</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. **DPTHACT** = 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>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. **ICECTNT** = 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 nonfrozen soil.</td>
</tr>
<tr>
<td>M</td>
<td>Medium</td>
<td>No excess ice; ice content (volume) equal to pore space of nonfrozen soil.</td>
</tr>
<tr>
<td>H</td>
<td>High</td>
<td>Excess ice: ice content greater than pore space in nonfrozen soil; ice usually in the form of lenses, vein ice, or massive ground ice.</td>
</tr>
</tbody>
</table>

24. **DPTHLFH** = Thickness of humus layer (L,F,H).

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 nil 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>Not applicable (e.g., borrow pit, organic deposits)</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>
</tbody>
</table>
25. DPTHORG = 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 due to sphagnum hummock formation.</td>
</tr>
<tr>
<td>2</td>
<td>0.6–1.6 m</td>
<td>Shallow peat (fens and bogs).</td>
</tr>
<tr>
<td>3</td>
<td>1.6–3.0 m</td>
<td>Deep peat.</td>
</tr>
<tr>
<td>4</td>
<td>&gt;3.0 m</td>
<td>Very deep peat.</td>
</tr>
</tbody>
</table>

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></td>
<td>Brunisolic</td>
</tr>
<tr>
<td>EDYB</td>
<td>Eluviated Dystric Brunisol</td>
</tr>
<tr>
<td>GLEYB</td>
<td>Gleyed Eluviated Dystric Brunisol</td>
</tr>
<tr>
<td>EEYB</td>
<td>Eluviated Eutric Brunisol</td>
</tr>
<tr>
<td>GLEYEB</td>
<td>Gleyed Eluviated Eutric Brunisol</td>
</tr>
<tr>
<td></td>
<td>Gleysolic</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>PEG</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></td>
<td>Luvisolic</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></td>
<td>Organic</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>
</tbody>
</table>
27. VARIANT = Classification variant or phase.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>Cryic</td>
<td>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.</td>
</tr>
<tr>
<td>l</td>
<td>Lithic</td>
<td>A soil that has a lithic contact within the control section.</td>
</tr>
<tr>
<td>p</td>
<td>Peaty</td>
<td>A soil that has a peaty layer 15-40 cm thick.</td>
</tr>
</tbody>
</table>

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 that are 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 due to differences in parent material (stratification, texture), depth of the LFH layer, peaty surface, coarse fragment content, etc.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>Deep</td>
<td>A soil that is relatively deep.</td>
</tr>
<tr>
<td>h</td>
<td>humus</td>
<td>A soil with a relatively deep duff layer.</td>
</tr>
<tr>
<td>s</td>
<td>Shallow</td>
<td>A soil that is relatively shallow.</td>
</tr>
<tr>
<td>v</td>
<td>Very deep</td>
<td>A soil that is very deep.</td>
</tr>
<tr>
<td>w</td>
<td>Very shallow</td>
<td>A soil that is very shallow.</td>
</tr>
<tr>
<td>x</td>
<td>complex</td>
<td>A soil that varies in a number of properties from the model (series concept)</td>
</tr>
<tr>
<td>1,2,3</td>
<td>Variant number</td>
<td>A soil that varies in one or more specific properties from the series concept.</td>
</tr>
</tbody>
</table>

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 that are 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.)

32. **TOTLAREA** = Total area (hectares) of soil polygon.

33. **COMPAREA** = Area (hectares) of polygon component.
34. **DR_CLASS** = Drainage class (numerical code used for modeling carbon stocks and fluxes).

<table>
<thead>
<tr>
<th>Code</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rock</td>
</tr>
<tr>
<td>2</td>
<td>VR</td>
</tr>
<tr>
<td>3</td>
<td>R</td>
</tr>
<tr>
<td>4</td>
<td>W</td>
</tr>
<tr>
<td>5</td>
<td>MW</td>
</tr>
<tr>
<td>6</td>
<td>I</td>
</tr>
<tr>
<td>7</td>
<td>P</td>
</tr>
<tr>
<td>8</td>
<td>VP</td>
</tr>
<tr>
<td>9</td>
<td>Water</td>
</tr>
<tr>
<td>10</td>
<td>Lake</td>
</tr>
</tbody>
</table>

35. **STND_AGE** = Age (years) since last fire of each soil polygon component. 1994 is the reference year. Some are age ranges. Data are from a variety of sources. (See Sections 1.6 and 7.2.1.)

- **13** 1981 burn scar from Landsat TM image and Terrestrial Ecology (TE)-05 fire history images.
- **30** 1964 burn scar from Forestry Canada fire history maps and Manitoba Natural Resources 1988 forest inventory data.
- **38** 1956 burn scar from Forestry Canada fire history maps and Natural Resources Manitoba 1988 forest inventory data.
- **43 +/- 7** Mean age +/- 1 std deviation from TE-13 tree core data.
- **45** Manitoba Natural Resources 1988 forest inventory data.
- **50** Estimate from Landsat TM image and Natural Resources Manitoba 1988 forest inventory data.
- **59 +/- 15** Mean age +/- 1 std deviation from TE-13 tree core data of forest stands along Hwy 391.
- **70** Natural Resources Manitoba 1988 forest inventory data - high end of age range 56 +/- 20 yrs.
- **86 +/- 10** Manitoba Natural Resources 1988 forest inventory data.
- **89 +/- 14** Mean age +/- 1 std deviation from TE-13 tree core data of forest stands near and around OJP tower site.
- **104 +/- 20** Natural Resources Manitoba 1988 forest inventory data.
- **120** Stand age of OBS near and around tower.
- **146 +/- 20** Natural Resources Manitoba 1988 forest inventory data.
- **199** Fen.
- **299** Lake.
36. ST\_AGE\_GRP = Stand age groupings used for estimating carbon stocks and modeling fluxes. Note: We assumed that the fens do not burn and therefore did not assign age since last fire for those polygon components that are fens.

13 1981 burn scar from Landsat TM image and TE-05 fire history images.
30 1964 burn scar from Forestry Canada fire history maps and Natural Resources Manitoba 1988 forest inventory data.
38 1956 burn scar from Forestry Canada fire history maps and Natural Resources Manitoba 1988 forest inventory data.
43 +/- 7 Mean age +/- 1 std deviation from TE-13 tree core data.
60 50 - 65 grouped.
70 Natural Resources Manitoba 1988 forest inventory data - high end of age range 56 +/- 20 yrs.
90 OJP tower site and other stands designated by Natural Resources Manitoba 1988 forest inventory as 86 yrs and older.
120 OBS tower site and other stands designated by Natural Resources Manitoba 1988 forest inventory as 104 yrs and older.

37. C\_SURFACE = Area-weighted score (kg C/m²) of carbon stock for surface horizons (including moss). Note: Stock = 0 for rock outcrops, open water, and lakes. Stock = 13 for fens and bog collapse.

38. C\_DEEP = Area-weighted score (kg C/m²) of carbon stock for deep soil horizons - humic and mineral A and B layers. Scores computed from average C stock of soil series. Note: Stock = 0 for rock outcrops, open water, and lakes.

39. C\_TOTAL = Area-weighted score (kg C/m²) of carbon stock for entire soil profile (C\_SURFACE + C\_DEEP). Note: Stock = 0 for rock outcrops, open water, and lakes.

40. FL\_SURFACE = Area-weighted score (kg C/m²/yr) of carbon flux for surface horizons (including moss). Note: Flux = 0 for rock outcrops, open water, lakes, fens, and collapse bogs.

41. FL\_DEEP = Area-weighted score (kg C/m²/yr) of carbon flux for deep soil horizons - humic and mineral A and B layers. Note: Flux = 0 for rock outcrops, open water, lakes, collapse bogs, and palsa bogs.

42. FL\_NET = Area-weighted score (kg C/m²/yr) of carbon flux for entire soil profile (F\_SURFACE + F\_DEEP). Note: Flux = 0 for rock outcrops, lakes, and open water.

NOTE: Negative (<0) flux denotes carbon released from the soil or surface horizons to the atmosphere (source). Positive (>0) flux denotes carbon stored in the soil or surface horizons (sink).
7.3.3 Unit of Measurement
See Section 7.3.2.

7.3.4 Data Source
This data product is derived from the soil maps that were produced by Dr. Hugo Veldhuis of Agriculture and Agri-Food Canada. See Section 1.5 for more information.

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

7.4 Sample Data Record
Not applicable.

8. Data Organization

8.1 Data Granularity
The smallest unit of data for this data set is the data set itself.

8.2 Data Format

8.2.1 Uncompressed Data Files
The image file contains binary 16-bit (2-byte) values with the low order byte The overall content of this product is:

File 1 ASCII text file listing files on tape
File 2 NSA-MSA Binary Soil Map
File 3 NSA-MSA Soils Polygon Data Table (ASCII)

The binary raster file that covers the NSA-MSA is distributed as 16-bit integers with the low-order byte first. The soils table file that indicates the soil parameters for the polygons in the map is distributed as an ASCII text file. The files have the following characteristics:

<table>
<thead>
<tr>
<th>File</th>
<th>Record Size</th>
<th>Bytes/</th>
<th># Records</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Bytes)</td>
<td>Pixel</td>
<td></td>
</tr>
<tr>
<td>File 1</td>
<td>80</td>
<td>ASCII text</td>
<td>8</td>
</tr>
<tr>
<td>File 2</td>
<td>2840</td>
<td>2</td>
<td>956</td>
</tr>
<tr>
<td>File 3</td>
<td>350</td>
<td>ASCII text</td>
<td>690</td>
</tr>
</tbody>
</table>

8.2.2 Compressed CD-ROM Files
On the BOREAS CD-ROMs, files 1 and 3 listed above are stored as ASCII text; however, file 2 has 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

See Section 9.1.1.

9.1.1 Derivation Techniques and Algorithms

The reader is referred to the detailed report submitted by Dr. Veldhuis for details on the derivation of the original maps (see Section 1.6). Refer to Davidson (1995) and Davidson and Lefebvre (1993) for methodology on calculating area-weighted scores for carbon stocks and fluxes. Refer to Trumbore and Harden (1997) and Harden et al. (1997) for details on algorithms and their derivation for modeling carbon stocks and fluxes.

9.2 Data Processing Sequence

9.2.1 Processing Steps

BOREAS Information System (BORIS) personnel processed the data by:

- Visually reviewing the data file contents.
- Copying the ASCII and compressing the binary files for release on CD-ROM.

9.2.2 Processing Changes

None.

9.3 Calculations

Refer to Davidson (1995) and Davidson and Lefebvre (1993) for methodology on calculating area-weighted scores for carbon stocks and fluxes. Refer to Trumbore and Harden (1997) and Harden et al. (1997) for details on algorithms and their derivation for modeling carbon stocks and fluxes.

9.3.1 Special Corrections/Adjustments

None.

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 original raster image was thoroughly checked and compared to the original vector data to avoid such problems. The vector data were an original mapping using data collected directly from the field along with air photos. Errors could arise from a typographical error in the field notes.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Any data validation or accuracy assessment would have to have been made by the original sources. Please refer to the reports mentioned in Section 5.

10.2.2 Confidence Level/Accuracy Judgment

The spatial accuracy of these data is considered very good.
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.

11. Notes

11.1 Limitations of the Data
The reports by Dr. Hugo Veldhuis and TGB-12 may indicate some limitations of the soil mapping. See Section 1.6.

Some of the stand age/fire history data are estimates and assumptions for those areas within the study area for which no data were available. Also, in other areas, estimates are at the high end of the age ranges listed in the Natural Resources Manitoba forest inventory field manual. (See Section 17.2.)

Carbon stocks and fluxes are area-weighted averages for each polygon component. Moss stocks and fluxes and deep carbon fluxes were calculated by applying algorithms for soil carbon inputs (I) and decomposition rates (k) based on field work using radiocarbon analyses. Reference I's and k's are in the middle of the range for each drainage/vegetation type. They may be under or over estimated. For further details see Trumbore and Harden (1997), Harden et al. (1997), and Rapalee et al. (in preparation).

Carbon stocks for the deep soil horizons are also area-weighted averages. That is, the average stock for a particular soil series for the deeper layers of the soil profile. In some cases, however, there was only one soil pit for a particular soil series. Also, since many of the profile descriptions of the study area were missing data on bulk density, we developed a nonlinear regression relating bulk density to carbon content for the soil profile descriptions that had both. Errors in average C stocks for the soil series may have arisen from our estimates of bulk density.

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 Other Relevant Information
For more information, please consult the soils report by Dr. Hugo Veldhuis and the documentation by Harden and Trumbore (TGB-12). See Section 1.6.

12. Application of the Data Set
This data set was created for BOREAS investigators who need soils data in the vicinity of the MSA for further modeling and to generate maps of area-weighted carbon stocks and fluxes.
13. Future Modifications and Plans

None.

14. Software

14.1 Software Description
IDRISI GIS software was used to modify the gridded soil polygon file produced from Dr. Veldhuis's original soil map. Gzip (GNU zip) uses the Lempel-Ziv algorithm (Welch, 1994) used in the zip and PKZIP commands.

14.2 Software Access
IDRISI is proprietary software with copyright protection. This software is a product of the IDRISI Project at Clark University, Worcester, MA. 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 raster format soil carbon and flux data from the NSA-MSA 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 made 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  
BOREAS - BOREal Ecosystem-Atmosphere Study  
BORIS - BOREAS Information System  
BPI - Bytes Per Inch  
CD-ROM - Compact Disk-Read-Only Memory  
DAAC - Distributed Active Archive Center  
DAT - Digital Archive Tape  
DLG - Digital Line Graph  
EOS - Earth Observing System  
EOSDIS - EOS Data and Information System  
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  
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  
TGB - Trace Gas Biogeochemistry  
TM - Thematic Mapper  
URL - Uniform Resource Locator  
UTM - Universal Transverse Mercator  
WWW - World Wide Web

20. Document Information

20.1 Document Revision Date
Written: 28-Apr-1997  
Last Updated: 04-May-1999

20.2 Document Review Dates
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:
If using data from the BOREAS CD-ROM series, also reference the data as:


Also, cite the BOREAS CD-ROM set as:


20.5 Document Curator

20.6 Document URL
The BOREAS TGB-12 team made measurements of soil carbon inventories, carbon concentration in soil gases, and rates of soil respiration at several sites. This data set provides: (1) estimates of soil carbon stocks by horizon based on soil survey data and analyses of data from individual soil profiles; (2) estimates of soil carbon fluxes based on stocks, fire history, drainage, and soil carbon inputs and decomposition constants based on field work using radiocarbon analyses; (3) fire history data estimating age ranges of time since last fire; and (4) a raster image and an associated soils table file from which area-weighted maps of soil carbon and fluxes and fire history may be generated. This data set was created from raster files, soil polygon data files, and detailed lab analysis of soils data that were received from Dr. Hugo Veldhuis, who did the original mapping in the field during 1994. Also used were soils data from Susan Trumbore and Jennifer Harden (BOREAS TGB-12). The binary raster file covers a 733-km² area within the NSA-MSA.