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

Forrest G. Hall and David E. Knapp, Editors

Volume 183

BOREAS TE-20 NSA Soil Lab Data

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National Aeronautics and
Space Administration

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Greenbelt, Maryland 20771

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Hugo Veldhuis

Summary

This data set contains the major soil properties of soil samples collected in 1994 at the tower flux sites in the NSA. The soil samples were collected by Hugo Veldhuis and his staff from the University of Manitoba. The mineral soil samples were largely analyzed by Barry Goetz, under the supervision of Dr. Harold Rostad at the University of Saskatchewan. The organic soil samples were largely analyzed by Peter Haluschak, under the supervision of Hugo Veldhuis at the Centre for Land and Biological Resources Research in Winnipeg, Manitoba.

During the course of field investigation and mapping, selected surface and subsurface soil samples were collected for laboratory analysis. These samples were used as benchmark references for specific soil attributes in general soil characterization. Detailed soil sampling, description, and laboratory analysis were performed on selected modal soils to provide examples of common soil physical and chemical characteristics in the study area.

The soil properties that were determined include soil horizon; dry soil color; pH; bulk density; total, organic, and inorganic carbon; electric conductivity; cation exchange capacity; exchangeable sodium, potassium, calcium, magnesium, and hydrogen; water content at 0.01, 0.033, and 1.5 MPascals; nitrogen; phosphorus; particle size distribution; texture; pH of the mineral soil and of the organic soil; extractable acid; and sulfur. These data are stored in ASCII text files.

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This data set contains the major soil properties of soil samples collected in 1994 at the tower flux sites in the NSA. The soil samples were collected by Hugo Veldhuis and his staff from the University of Manitoba. The mineral soil samples were largely analyzed by Barry Goetz, under the supervision of Dr. Harold Rostad at the University of Saskatchewan. The organic soil samples were largely analyzed by Peter Haluschak, under the supervision of Hugo Veldhuis at the Centre for Land and Biological Resources Research in Winnipeg, Manitoba. During the course of field investigation and mapping, selected surface and subsurface soil samples were collected for laboratory analysis. These samples were used as benchmark references for specific soil attributes in general soil characterization. Detailed soil sampling, description, and laboratory analysis were performed on selected modal soils to provide examples of common soil physical and chemical characteristics in the study area. The soil properties that were determined include soil horizon; dry soil color; pH; bulk density; total, organic, and inorganic carbon; electric conductivity; cation exchange capacity; exchangeable sodium, potassium, calcium, magnesium, and hydrogen; water content at 0.01, 0.033, and 1.5 MPascals; nitrogen; phosphorus; particle size distribution; texture; pH of the mineral soil and of the organic soil; extractable acid; and sulfur. These data are stored in ASCII text files.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-20 NSA Soil Lab Data

1.2 Data Set Introduction

This data set was collected by Hugo Veldhuis, who worked under contract with the BOReal Ecosystem-Atmosphere Study (BOREAS) Terrestrial Ecology (TE)-20 team to collect soil samples at the BOREAS Northern Study Area (NSA) tower sites and to provide the results of various laboratory tests performed on the soil samples.

1.3 Objective/Purpose

There was a general need within BOREAS for soil properties to be obtained. These data were not collected with any particular application in mind. Various groups in BOREAS needed measurements of soil carbon content, bulk density, electrical conductivity (EC), and other soil properties for use in ecological models.

1.4 Summary of Parameters

The following soil parameters were measured: bulk density, pH of the soil, total carbon (TC), organic carbon (OC), inorganic carbon (IC), buffered cation exchange capacity (CEC), exchangeable sodium (Na), exchangeable potassium (K), exchangeable calcium (Ca), exchangeable magnesium (Mg), field moisture, saturated moisture, wilting moisture, total nitrogen (N), particle size distribution, extractable acidity, and total sulfur (S).

1.5 Discussion

During the field investigation and mapping, selected surface and subsurface soil samples were collected for laboratory analysis. These samples were used as benchmark references for specific soil attributes in general soil characterization. Detailed soil sampling, description and laboratory analysis were performed on selected modal soils to provide examples of common soil physical and chemical characteristics in the study area.

1.6 Related Data Sets

Agriculture Canada Central Saskatchewan Vector Soils Data
CanSIS Regional Soils Data in Vector Format
BOREAS Regional Soils Data in Raster Format and AEAC Projection
BOREAS Soils Data over the SSA in Raster Format and AEAC Projection
BOREAS TE-01 Soils Data over the SSA Tower Sites in Raster Format
BOREAS TE-01 SSA Soil Lab Data
BOREAS TE-20 Soils Data over the NSA and Tower Sites in Vector Format
BOREAS TE-20 Soils Data over the NSA and Tower Sites in Raster Format
BOREAS TGB-12 Soil Carbon and Flux Data of NSA-MSA in Raster Format
BOREAS TGB-12 Soil Carbon Data over the NSA

2. Investigator(s)

2.1 Investigator(s) Name and Title

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2.2 Title of Investigation

Soils of Tower Sites and Super Site, Northern Study Area, Thompson, Manitoba, Canada

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3. Theory of Measurements

A number of different soil properties were measured for use by BOREAS investigators. The theory and methods used to measure these properties are as follows:

- Bulk Density: An intact known volume of soil is removed, dried, and weighed; the density can then be calculated.
- TC: All types of carbon will be combusted into carbon dioxide (CO_2) in a flow of oxygen (O_2) at 2,500 °F.
- IC: IC reacts with acid producing CO_2, which is quantified through titration.
- OC: Equals measured TC minus measured IC.
- EC: The soil's ability to carry an electrical current which is indicative of salt content.
- CEC: If a soil is washed with one cation (Ba), and the other cations are leached, the first cation fills the exchange sites of the leached cation, and equals the soil's CEC.
- Exchangeable Cations: Equals the quantity of cations in the leachate after they have been exchanged off the soil.
- Soil Moisture Retentions: Equals the amount of water in soils under a suction equal to 1/10, 1/3, and 15 atmospheres (i.e., field moisture 10th, saturated moisture, and wilting moisture, as described respectively in the original soil analysis report).
- Soil Size Fractions: Clay and silt are measured based on the principle that the speed at which a particle will fall in water will depend on the size of the particle.

4. Equipment

4.1 Sensor/Instrument Description

- Bulk density: 10 cm diameter tube, 10 cm long.
- TC: LECO CR12 Carbon Determinator 781-600
- CEC and exchangeable cations: Cation concentrations were measured by atomic adsorption-Perkin Elmer 3100.

Equipment used in other procedures is listed in the references and manuals listed in Section 17.

4.1.1 Collection Environment
None given.

4.1.2 Source/Platform
Not applicable.

4.1.3 Source/Platform Mission Objectives
Not applicable.

4.1.4 Key Variables
Soil Horizon
Soil Color (Dry)
pH
Bulk Density
Total Carbon
Organic Carbon
Inorganic Carbon
Electric Conductivity
Cation Exchange Capacity
Exchangeable Sodium
Exchangeable Potassium
Exchangeable Calcium
Exchangeable Magnesium
Exchangeable Hydrogen
Water Content at a pressure of 0.1 atmospheres (0.01 MPascals)
Water Content at a pressure of 0.33 atmospheres (0.033 MPascals)
Water Content at a pressure of 15 atmospheres (1.5 MPascals)
Nitrogen
Phosphorus
Percentage of Very Coarse Sand
Percentage of Coarse Sand
Percentage of Medium Sand
Percentage of Fine Sand
Percentage of Very Fine Sand
Percentage of Total Sand
Percentage of Total Silt
Percentage of Total Clay
Texture
Horizon Number
pH of the Mineral Soil ($CaCl_2$)
pH of the Organic Soil ($CaCl_2$)
pH of the Mineral Soil (H_2O)
pH of the Organic Soil (H_2O)
Extractable Acid
Sulfur

4.1.5 Principles of Operation
None given.

4.1.6 Sensor/Instrument Measurement Geometry
Not applicable.

4.1.7 Manufacturer of Sensor/Instrument
None given.

4.2 Calibration
Calibration information was provided for the following instruments:
- Total Carbon: LECO 501-034 12%

Dry soil colors were measured according to the Munsell color chart. All other standards were prepared in the laboratory from pure analytical compounds and tested against National Institute of Standards and Technology (NIST) standards.

4.2.1 Specifications
None given.

4.2.1.1 Tolerance
None given.

4.2.2 Frequency of Calibration
None given.

4.2.3 Other Calibration Information
None.

5. Data Acquisition Methods

Bulk Density: Cylinders of known volume and weight are pressed into the soil and filled with soil in its natural state. The soil and cylinder are dried at 105 °C and weighed. The soil weight is then calculated and divided by the cylinder volume (Manual on Soil Sampling and Methods of Analysis).

TC: Measured by combustion of dried soil samples in a LECO CR12 Carbon Determinator (LECO Corporation Application Bulletin form no. 203-601-071).

IC: Measured through digestion in acid, and evolved CO_2 is measured directly as carbonic acid in a two-endpoint titration (Tiessen et al., 1983).

OC: Equals measured TC minus measured IC.

Total Nitrogen and Phosphorus: Digestion in H_2SO_4 and H_2O_2 (Thomas et al., 1967). Products $NH_4^+$and P were measured colorimetrically by the ammonia-salicylate method (Technicon, 1973) and acid-molybdate blue method (Murphy and Riley, 1962), respectively.

Electrical conductivity and pH: Standard laboratory meter.

CEC: The cations on the exchange are replaced with barium (Ba), which is then exchanged off the soil with NH_4 and the amount of Ba is measured (p. 54, Manual on Soil Sampling and Methods of Analysis).

Exchangeable Cations: Measured in leachate after Ba has exchanged them off the soil; Na^+, K^+, Ca_2^+, Mg_2^+ by atomic absorption and H+ by back titration with HCl to pH 5.1 (p. 83, Manual on Soil Sampling and Methods of Analysis).

Soil Moisture Retentions: Pressure plate extraction (p. 45, Manual on Soil Sampling and Methods of Analysis).

Soil Size Fractions: Pipette method (p. 6, Manual on Soil Sampling and Methods of Analysis).

6. Observations

6.1 Data Notes

The table below lists soil classification (by order, sub-group, and soil type), site location, soil polygon (Polynum), and BOREAS site location of soil pits in this study. This information enables the user to spatially link soils data from this study to the TE-20 Soils Data over the NSA-MSA and Tower Sites in Raster Format and TGB-12 Soil Carbon and Flux Data of NSA-MSA in Raster Format data sets. See TE-20 soils data documentation, TE-20 Soils Report, and Soil Classification Working Group (1998) for detailed description of soil classification.

Soil Pit	Order	Subgroup	Soil Type	Site	Polynum	BOREAS Site	Location
FEN02	ORGANIC	TYF	FEN	FEN	21	NSA-FEN-FLXTR	9-TE20-SOLO2
FEN04	CRYSOLIC	MEOC	PAA	FEN	16	NSA-FEN-FLXTR	9-TE20-SOLO4
FEN06	CRYSOLIC	MEOC	PAA	FEN	16	NSA-FEN-FLXTR	9-TE20-SOLO6
FEN07	ORGANIC	TYF	BGC	FEN	10	NSA-FEN-FLXTR	9-TE20-SOLO7
FEN08	CRYOSOLIC	TMEOC	PLH	FEN	12	NSA-FEN-FLXTR	9-TE20-SOLO8
FEN09	ORGANIC	TYF	FCD	FEN	8	NSA-FEN-FLXTR	9-TE20-SOLO9
OBS01	LUVISOLIC	OGL	WBW	OBS	31	NSA-OBS-FLXTR	9-TE20-SOLO1
OBS02	LUVISOLIC	OGL	SWK	OBS	19	NSA-OBS-FLXTR	9-TE20-SOLO2
OBS03	CRYOSOLIC	RSC	PLH	OBS	12	NSA-OBS-FLXTR	9-TE20-SOLO3
OBS04	CRYSOLIC	TFIOC	NIC	OBS	16	NSA-OBS-FLXTR	9-TE20-SOLO4
OBS05	CRYSOLIC	TFIOC	NIC	OBS	21	NSA-OBS-FLXTR	9-TE20-SOLO5
OBS06	GLEYSOLIC	OLG	LPR	OBS	15	NSA-OBS-FLXTR	9-TE20-SOLO6
OBS07	LUVISOLIC	OGL	WBW	OBS	19	NSA-OBS-FLXTR	9-TE20-SOLO7
OJP01	BRUNISOLIC	EDYB	PCP	OJP	9	NSA-OJP-FLXTR	9-TE20-SOLO1
OJP02	BRUNISOLIC	EDYB	PCP	OJP	13	NSA-OJP-FLXTR	9-TE20-SOLO2
OJP03	BRUNISOLIC	EDYB	PCP	OJP	9	NSA-OJP-FLXTR	9-TE20-SOLO3
OJP04	BRUNISOLIC	EDYB	PCP	OJP	9	NSA-OJP-FLXTR	9-TE20-SOLO4
OJP05	BRUNISOLIC	EDYB	PCP	OJP	2	NSA-OJP-FLXTR	9-TE20-SOLO5
OJP06	BRUNISOLIC	EDYB	PCP	OJP	3	NSA-OJP-FLXTR	9-TE20-SOLO6
OJP07	GLEYSOLIC	OG	WTP	OJP	12	NSA-OJP-FLXTR	9-TE20-SOLO7
OTA01	LUVISOLIC	OGL	WBW	OTA	5	NSA-90A-9TETR	9-TE20-SOLO1
OTA02	LUVISOLIC	OGL	PPU	OTA	13	NSA-90A-9TETR	9-TE20-SOLO2
US01	LUVISOLIC	OGL	SWK	SST	41	NSA-9BS-9TETR	9-TE20-SOLO1
YJP01	GLEYSOLIC	OG	PCH	YJP	12	NSA-YJP-FLXTR	9-TE20-SOLO1
YJP02	BRUNISOLIC	EDYB	PCP	YJP	1	NSA-YJP-FLXTR	9-TE20-SOLO2
YJP03	BRUNISOLIC	EDYB	PCP	YJP	14	NSA-YJP-FLXTR	9-TE20-SOLO3
YJP04	BRUNISOLIC	GLEDYB	PCB	YJP	9	NSA-YJP-FLXTR	9-TE20-SOLO4
YJP05	BRUNISOLIC	GLEDYB	LWP	YJP	9	NSA-YJP-FLXTR	9-TE20-SOLO5
YJP06	BRUNISOLIC	EDYB	CLK	YJP	17	NSA-YJP-FLXTR	9-TE20-SOLO6

SOILDEV = Soil development (soil classification).

Order	Subgroup
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

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

VARIANT

Code	Class
c	Cryic
l	Lithic
p	Peaty

SOIL TYPE (See TE-20 Soils Report for descriptions of soil types.)

ATK - Atik
BDY - Baldy
BGC - Bog Collapse
BRN - Brannigan Creek
BTT - Button
CLK - Clarke
CMK - Cormorant Lake
FCD - Fen Collapse
FEN - Fen
GRS - Grass River
LPR - La Perouse
LWP - Low Pine
MDR - Medard
NIC - Nichols Lake
PAA - Palsa
PCB - Partridge Beak
PCH - Partridge Head
PCP - Partridge Crop
PKW - Pakwa
PLH - Palsa Hummock
PLT - Plateau
PPU - Pipun
ROK - Roe Lake
SWK - Sipiwesk
SYB - Sandy Bog
TBL - Turnbull
TFN - Thaw Fen
TYL - Tyrrell
WBW - Wabowden
WRL - Warren Landing
WTP - Wet Pine
YGP - Young Pine

SOIL PHASE

Code

d	Deep
h	Humus
s	Shallow
v	Very deep
w	Very shallow
x	Complex

Note: The Trace Gas Biogeochemistry (TGB)-12 and TE-20 raster data sets cover the same area of the NSA-Modeling Sub-Area (MSA). Both data sets contain a raster image and an attribute file that describes each soil polygon. The TGB-12 raster data were modified to account for the 1981 burn. In this data set, polygons with POLYNUM 238 - 248 are within the burn.

6.2 Field Notes

None given.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The tower flux sites are located in the NSA at the following North American Datum of 1983 (NAD83) coordinates:

	Longitude	Latitude
Old Black Spruce (OBS)	98.48139 °W	55.88007 °N
Old Jack Pine (OJP)	98.623958°W	55.9284153°N
Fen	98.420716°W	55.9148083°N
Young Jack Pine (YJP)	98.287056°W	55.8957528°N
Aspen (aux. site T2Q6A)	98.674786°W	55.8869081°N

7.1.2 Spatial Coverage Map

None.

7.1.3 Spatial Resolution

These data represent point locations.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

All measured parameters will change only over the long term, so any data could be valuable to generalize the soil characteristics of the area for many years in the future.

7.2.2 Temporal Coverage Map

The measurement of these soil properties was based on soil samples that were collected in 1994.

7.2.3 Temporal Resolution

The soil samples were collected at a certain point in time. However, the soil properties that were derived from the samples do not tend to change significantly with time.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

Column Name
SITE_NAME
SUB_SITE
MEASUREMENT_YEAR
PIT
HORIZON
START_DEPTH
END_DEPTH
BULK_DENSITY
TOTAL_SOIL_C_CONTENT
SOIL_ORG_C_CONTENT
SOIL_INORG_C_CONTENT
CATION_EX_CAPACITY
EXCHANGE_SODIUM
EXCHANGE_POTASSIUM
EXCHANGE_CALCIUM
EXCHANGE_MAGNESIUM
WATER_CONTENT_10KPA
WATER_CONTENT_33KPA
WATER_CONTENT_1500KPA
SOIL_NITROGEN_CONTENT
SOIL_PHOSPHORUS_CONTENT
VERY_COARSE_SAND
COARSE_SAND
MEDIUM_SAND
FINE_SAND
VERY_FINE_SAND
TOTAL_SAND
TOTAL_SILT
TOTAL_CLAY
SOIL_TEXTURE
HORIZON_NUM
MINRL_SOIL_AND_CACL2_PH
ORG_SOIL_AND_CACL2_PH
MINRL_SOIL_AND_H2O_PH
ORG_SOIL_AND_H2O_PH
SOIL_EXTRACT_ACIDITY
SOIL_SULFUR_CONTENT
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
MEASUREMENT_YEAR	The year in which the data were collected.
PIT	The pit identifier from which the sample was taken.
HORIZON	The soil horizon from which the sample was taken.
START_DEPTH	The start depth from the surface where the sample was collected.
END_DEPTH	The end depth from the surface where the sample was collected.
BULK_DENSITY	Bulk density of the soil sample.
TOTAL_SOIL_C_CONTENT	The percent total carbon in the soil sample.
SOIL_ORG_C_CONTENT	The percent organic carbon in the soil sample.
SOIL_INORG_C_CONTENT	The percent inorganic carbon in the soil sample.
CATION_EX_CAPACITY	The cation exchange capacity in the soil sample.
EXCHANGE_SODIUM	The exchangeable sodium in the soil sample.
EXCHANGE_POTASSIUM	The exchangeable potassium in the soil sample.
EXCHANGE_CALCIUM	The exchangeable calcium in the soil sample.
EXCHANGE_MAGNESIUM	The exchangeable magnesium in the soil sample.
WATER_CONTENT_10KPA	The water content of the soil in percent by weight of water held at 0.01 MegaPascals.
WATER_CONTENT_33KPA	The water content of the soil in percent by weight of water held at 0.033 MegaPascals.
WATER_CONTENT_1500KPA	The water content of the soil in percent by weight of water held at 1.5 MegaPascals.
SOIL_NITROGEN_CONTENT	The nitrogen content of the soil sample.
SOIL_PHOSPHORUS_CONTENT	The phosphorus content of the soil sample.
VERY_COARSE_SAND	The amount of very coarse sand in the soil sample.
COARSE_SAND	The amount of coarse sand in the soil sample.
MEDIUM_SAND	The amount of medium sand in the soil sample.
FINE_SAND	The amount of fine sand in the soil sample.
VERY_FINE_SAND	The amount of very fine sand in the soil sample.
TOTAL_SAND	The total amount of sand in the soil sample.
TOTAL_SILT	The total amount of silt in the soil sample.
TOTAL_CLAY	The total amount of total clay in the soil sample.

SOIL_TEXTURE	The texture of the soil sample.
HORIZON_NUM	The number of the horizon.
MINRL_SOIL_AND_CACL2_PH	The pH of a 1:2 soil to CaCl2 mixture using mineral soil.
ORG_SOIL_AND_CACL2_PH	The pH of a 1:10 soil to CaCl2 mixture using organic soil.
MINRL_SOIL_AND_H2O_PH	The pH of a 1:2 soil to H2O mixture using mineral soil.
ORG_SOIL_AND_H2O_PH	The pH of a 1:10 soil to H2O mixture using organic soil.
SOIL_EXTRACT_ACIDITY	The extractable acidity in the soil sample.
SOIL_SULFUR_CONTENT	The sulfur content in the soil sample.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

The following table should help in describing the soil horizon codes:

Organic Horizons	
Horizon Code	**Code Description**
O	This is an organic horizon developed mainly from mosses, rushes, and woody materials.
Of	The fibric horizon is the least decomposed of all the organic soil materials. It has large amounts of well-preserved fiber that are readily identifiable as to botanical origin. A fibric horizon has 40% or more of rubbed fiber by volume and a pyrophosphate index of 5 or more. If the rubbed fiber volume is 75% or more, the pyrophosphate criterion does not apply.
Om	The mesic horizon is the intermediate stage of decomposition with intermediate amounts of fiber, bulk density and water-holding capacity. The material is partly altered both physically and biochemically. A mesic horizon is one that fails to meet the requirements of fibric or humic.
Oh	The humic horizon is the most highly decomposed of the organic soil materials. It has the least amount of fiber, the highest bulk density, and the lowest saturated water-holding capacity. It is very stable and changes very little physically or chemically with time unless it is drained. The humic horizon has less than 10% rubbed fiber by volume and a pyrophosphate index of 3 or less.
LFH	These organic horizons developed primarily from leaves, twigs, woody materials, and a minor component of mosses under imperfectly to well-drained forest conditions.
L	This is an organic horizon characterized by an accumulation of organic matter in which the original structures are easily discernible.

F	This is an organic horizon characterized by an accumulation of partly decomposed organic matter. The original structures in part are difficult to recognize. The horizon may be partly comminuted by soil fauna as in moder, or it may be a partly decomposed mat permeated by fungal hyphae as in mor.
H	This is an organic horizon characterized by an accumulation of decomposed organic matter in which the original structures are indiscernible. This material differs from the F horizon by its greater humification chiefly through the action of organisms. It is frequently intermixed with mineral grains, especially near the junction with the mineral horizon.

Mineral Horizons

Mineral horizons are those that contain less than 30% organic matter by weight as specified for organic horizon.

Horizon Code	Code Description
A	This is a mineral horizon or horizons formed at or near the surface in the zone of leaching or removal of materials in solution and suspension or of maximum in situ accumulation of organic matter, or both. Included are: • horizons in which organic matter has accumulated as a result of biological activity (Ah); • horizons that have been eluviated of clay, iron, aluminum, or organic matter, or all of them (Ae); • horizons having characteristics of 1) and 2) above but transitional to underlying B or C (AB or A and B); • horizons markedly disturbed by cultivation or pasture (Ap).
B	This is a mineral horizon or horizons characterized by one or more of the following: • an enrichment in silicate clay, iron, aluminum, or humus, alone or in combination (Bt, Bf, Bfh, Bhf, and Bh); • a prismatic or columnar structure that exhibits pronounced coatings or stainings and significant amount of exchangeable Na (Bn); • an alteration by hydrolysis, reduction, or oxidation to give a change in color or structure from horizons above or below, or both, and does not meet the requirements of 1) and 2) above (Bm, Bg).
C	This is a mineral horizon or horizons comparatively unaffected by the pedogenic processes operative in A and B, excepting (i) the process of gleying, and (ii) the accumulation of calcium and magnesium carbonates and more soluble salts (Cca, Csa, Cg, and C). Marl and diatomaceous earth are considered to be C horizons.
R	This is consolidated bedrock that is too hard to break with the hands or to dig with a spade when moist and that does not meet the requirement of a C horizon. The boundary between the R layer and overlying unconsolidated material is called a lithic contact.

W	This is a layer of water in Gleysolic, Organic, or Cryosolic soils. It is called a hydric layer in Organic soils.
Lower-Case Suffixes	
Horizon Code	**Code Description**
b	Buried soil horizon.
c	A cemented (irreversible) pedogenic horizon. The ortstein of a Podzol, and a layer cemented by calcium carbonate and a duripan are examples.
ca	A horizon with secondary carbonate enrichment where the concentration of lime exceeds that present in the unenriched parent material. It is more than 10 cm thick, and if it has a $CaCO_3$ equivalent of less than 15 percent it should have at least 5 percent more $CaCO_3$ equivalent than the parent material (IC). If it has more than 15 percent $CaCO_3$ equivalent it should have 1/3 more $CaCO_3$ equivalent than the IC. If no IC is present, this horizon is more than 10 cm thick and contains more than 5 percent by volume of secondary carbonates in concretions or soft, powdery forms.
cc	Cemented (irreversible) pedogenic concretions.
e	A horizon characterized by the eluviation of clay, iron, aluminum, or organic matter alone or in combination. When dry, it is usually higher in color value by 1 or more units than an underlying B horizon. It is used with A (Ae).
f	A horizon enriched with amorphous material, principally Al and Fe combined with organic matter. It usually has a hue of 7.5YR or redder or its hue is 10YR near the upper boundary and becomes yellower with depth. When moist, the chroma is higher than 3 or the value is 3 or less. It contains 0.6% or more pyrophosphate-extractable Al+Fe in textures finer than sand and 0.4% or more in sands (coarse sand, sand, fine sand, and very fine sand). The ratio of pyrophosphate-extractable Al+Fe to clay (less than 0.002 mm) is more than 0.05 and OC exceeds 0.5%. Pyrophosphate-extractable Fe is at least 0.3%, or the ratio of OC to pyrophosphate-extractable Fe is less than 20, or both are true. It is used with B alone (Bf), with B and h (Bhf), with B and g (Bfg), and with other suffixes. The criteria for "f" do not apply to Bgf horizons.
The following horizons are differentiated on the basis of OC content: Bf - 0.5% to 5% OC. Bhf - more than 5% OC.	
Horizon Code	**Code Description**

g	A horizon characterized by gray colors, or prominent mottling, or both, indicative of permanent or periodic intense reduction. Chromas of the matrix are generally 1 or less. It is used with A and e (Aeg); with B alone (Bg); with B and f (Bfg); with B, h, and f (Bhfg); with B and t (Btg); with C alone (Cg); with C and k (Ckg); and several others. In some reddish parent materials, matrix colors of reddish hues and high chromas may persist, despite long periods of reduction. In these soils, horizons are designated as g if there is gray mottling or if there is marked bleaching on ped faces or along cracks.
Aeg	This horizon must meet the definitions of A, e, and g.
Bg	These horizons are analogous to Bm horizons but they have colors indicative of poor drainage and periodic reduction. They include horizons occurring between A and C horizons in which the main features are: (i) colors of low chroma, that is: chromas of 1 or less, without mottles on ped surfaces or in the matrix if peds are lacking; or chromas of 2 or less in hues of 10YR or redder, on ped surfaces or in the matrix if peds are lacking, accompanied by more prominent mottles than those in the C horizon; or hues bluer than 10Y, with or without mottles on ped surfaces or in the matrix if peds are lacking. (ii) colors indicated in (i) and a change in structure from that of the C horizons. (iii) color indicated in (i) and illuviation of clay too slight to meet the requirements of Bt; or accumulation or iron oxide too slight to meet the limits of Bgf. (iv) colors indicated in (i) and removal of carbonates. Bg horizons occur in some Orthic Humic Gleysols and some Orthic Gleysols.
Bfg, Bhfg, Btg, and others.	When used in any of these combinations the limits set for f, hf, t, and others must be met.
Bgf	The dithionite-extractable Fe of this horizon exceeds that of the IC by 1% or more. Pyrophosphate-extractable Al + Fe is less than the minimum limit specified for 'f' horizons. This horizon occurs in Fera Gleysols and Fera Humic Gleysols, and possibly below the Bfg of gleyed Podzols. It is distinguished from the Bfg of gleyed Podzols on the basis of the extractability of the Fe and Al. The Fe in the Bgf horizon is thought to have accumulated as a result of the oxidation of ferrous iron. The iron oxide formed is not associated intimately with organic matter or with Al, and it is sometimes crystalline. The Bgf horizons are usually prominently mottled, with more than half of the soil material occurring as mottles of high chroma.
Cg, Ckg, Ccag, Csg, Csag	When g is used with C alone, or with C and one of the lowercase suffixes k, ca, s, or sa, it must meet the definition for C and for the particular suffix.
h	A horizon enriched with organic matter. It is used with A alone (Ah); or with A and e (Ahe); or with B alone (Bh); or with B and f (Bhf).
Ah	A horizon enriched with organic matter that either has a color value at least one unit lower than the underlying horizon or contains 0.5% more OC than the IC, or both. It contains less than 17% OC by weight.
Ahe	An Ah horizon that has undergone eluviation as evidenced, under natural conditions, by streaks and splotches of differing shades of gray and often by platy structure. It may be overlain by a darker-colored Ah and underlain by a lighter colored Ae.

Bh	This horizon contains more than 1% organic carbon, less than 0.3% pyrophosphate-extractable Fe, and has a ratio of OC to pyrophosphate-extractable of 20 or more. Generally the color value and chroma are less than 3 when moist.
Bhf	Defined under 'f'.
j	Used as a modifier of the suffixes e, f, g, n, and t to denote an expression of, but failure to meet, the specified limits of the suffix it modifies. It must be placed to the right of and adjacent to the suffix it modifies. For example, Bfgj means a Bf horizon with weak expression of gleying; Bfjgj means a B horizon with weak expression of both 'f' and 'g' features.
Aej	An eluvial horizon that is thin, discontinuous, or slightly discernible.
Btj	A horizon with some illuviation of clay, but not enough to meet the limits of Bt. Btgj, Bmgj Horizons that are mottled but do not meet the criteria of Bg.
Bfj	A horizon with some accumulation of pyrophosphate-extractable Al and Fe but not enough to meet the limits of Bf. Bntj or Bnj Horizons in which development of solonetzic B properties is evident but insufficient to meet the limits for Bn or Bnt.
k	Denotes the presence of carbonate, as indicated by visible effervescence when dilute HCl is added. Most often it is used with B and m (Bmk) or C (Ck), and occasionally with Ah or Ap (Ahk, Apk), or organic horizons (Ofk, Omk).

m	A horizon slightly altered by hydrolysis, oxidation, or solution, or all three, to give a change in color or structure, or both. It has:
	• Evidence of alteration in one of the following forms:
	  • Higher chromas and redder hues than the underlying
	  • Removal of carbonates, either partially (Bmk) or completely (Bm).
	• Illuviation, if evident, too slight to meet the requirements of a Bt or a podzolic B.
	• Some weatherable minerals.
	• No cementation or induration and lacks a brittle consistence when moist. This suffix can be used as Bm, Bmgj, Bmk, and Bms.

n	A horizon in which the ratio of exchangeable Ca to exchangeable Na is 10 or less. It must also have the following distinctive morphological characteristics: prismatic or columnar structure, dark coatings on ped surfaces, and hard to very hard consistence when dry. It is used with B, as Bn or Bnt.
p	A horizon disturbed by man's activities, such as cultivation, logging, habitation, etc. It is used with A and O.
s	A horizon with salts, including gypsum, which may be detected as crystals or veins, as surface crusts of salt crystals, by depressed crop growth, or by the presence of salt-tolerant plants. It is commonly used with C and k (Csk), but can be used with any horizon or combination of horizon and lowercase suffix.

sa	A horizon with secondary enrichment of salts more soluble than calcium and magnesium carbonates, in which the concentration of salts exceeds that present in the unenriched parent material. The horizon is 10 cm or more thick. The conductivity of the saturation extract must be at least 4 ms/cm and must exceed that of the C horizon by at least one-third.
t	An illuvial horizon enriched with silicate clay. It is used with B alone (Bt), with B and g (Btg), with B and n (Bnt), etc.

Bt	A Bt horizon is one that contains illuvial layer lattice clays. It forms below an eluvial horizon, but may occur at the surface of a soil that has been partially truncated. It usually has a higher ratio of fine clay to total clay than IC. It has the following properties:
	• If any part of an eluvial horizon remains and there is no lithologic discontinuity between it and the Bt horizon, the Bt horizon contains more total and fine clay than the eluvial horizons, as follows:
	  • If any part of the eluvial horizon has less than 15% total clay in the fine earth fraction (2 mm), the Bt horizon must contain at least 3% more clay, e.g., Ae 10% clay, Bt minimum 13% clay.
	  • If the eluvial horizon has more than 15% and less than 40% total clay in the fine earth fraction, the ratio of the clay in the Bt horizon to that in the eluvial horizon must be 1.2 or more, e.g., 20% clay increase in the Bt over Ae.
	  • If the eluvial horizon has more than 40% total clay in the fine earth fraction, the Bt horizon must contain at least 8% more clay than the eluvial horizon, e.g., Ae 50% clay, Bt at least 58% clay.
	• A Bt horizon must be at least 5 cm thick. In some sandy soils where clay accumulation occurs in the lamellae, the total thickness of the lamellae should be more than 10 cm in the upper 150 cm of the profile.
	• In massive soils the Bt horizon should have oriented clays in some pores and also as bridges between the sand grains.
	• If peds are present, a Bt horizon shows clay skins on some of the vertical and horizontal ped surfaces and in the fine pores, or shows oriented clays in 1% or more of the cross section, as viewed in thin section.
	• If a soil shows a lithologic discontinuity between the eluvial horizon and the Bt horizon, or if only a plow layer overlies the Bt horizon, the Bt horizon need show only clay skins in some part, either in some fine pores or on some vertical and horizontal ped surfaces. Thin sections should show that some part of the horizon has about 1% or more of oriented clay bodies.

Btj	Btj and Btg are defined under j and g.
u	A horizon that is markedly disrupted by physical or faunal processes other than cryoturbation. Evidence of marked disruption such as the inclusion of material from other horizons, absence of the horizon, etc., must be evident in at least half of the cross section of the pedon. Such turbation can result from blowdown of trees, mass movement of soil on slopes, and burrowing animals. It can be used with any horizon or subhorizon with the exception of A or B alone; e.g., Aeu, Bfu, BCu.

x	A horizon of fragipan character. A fragipan is a loamy subsurface horizon of high bulk density and very low organic matter content. When dry, it has a hard consistence and seems to be cemented. When moist, it has moderate to weak brittleness. It frequently has bleached fracture planes and is overlain by a friable B horizon. Air dry clods of fragic horizons slake in water.
y	A horizon affected by cryoturbation as manifested by disrupted and broken horizons, incorporation of materials from other horizons, and mechanical sorting in at least half of the cross section of the pedon. It is used with A, B, and C alone or in combination with other subscripts, e.g., Ahy, Ahgy, Bmy, Cy, Cgy, Cygj, etc.
z	A frozen layer. It may be used with any horizon or layer, e.g., Ohz, Bmz, Cz, Wz.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
MEASUREMENT_YEAR	[unitless]
PIT	[none]
HORIZON	[none]
START_DEPTH	[meters]
END_DEPTH	[meters]
BULK_DENSITY	[kilograms][meter^-3]
TOTAL_SOIL_C_CONTENT	[percent]
SOIL_ORG_C_CONTENT	[percent]
SOIL_INORG_C_CONTENT	[percent]
CATION_EX_CAPACITY	[millimoles +ve charge][kilograms^-1 of soil]
EXCHANGE_SODIUM	[millimoles +ve charge][kilograms^-1 of soil]
EXCHANGE_POTASSIUM	[millimoles +ve charge][kilograms^-1 of soil]
EXCHANGE_CALCIUM	[millimoles +ve charge][kilograms^-1 of soil]
EXCHANGE_MAGNESIUM	[millimoles +ve charge][kilograms^-1 of soil]
WATER_CONTENT	[percent]
WATER_CONTENT	[percent]
WATER_CONTENT	[percent]
SOIL_NITROGEN	[percent by weight]
SOIL_PHOSPHORUS_CONTENT	[percent by weight]
VERY_COARSE_SAND	[percent]
COARSE_SAND	[percent]
MEDIUM_SAND	[percent]
FINE_SAND	[percent]
VERY_FINE_SAND	[percent]
TOTAL_SAND	[percent]
TOTAL_SILT	[percent]
TOTAL_CLAY	[percent]
SOIL_TEXTURE	[none]
HORIZON_NUM	[unitless]
MINRL_SOIL_AND_CACL2_PH	[pH]
ORG_SOIL_AND_CACL2_PH	[pH]

MINRL_SOIL_AND_H2O_PH	[pH]
ORG_SOIL_AND_H2O_PH	[pH]
SOIL_EXTRACT_ACIDITY	[millimoles][kilogram^-1]
SOIL_SULFUR_CONTENT	[percent by weight]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
MEASUREMENT_YEAR	[Supplied by Investigator]
PIT	[Supplied by Investigator]
HORIZON	[Supplied by Investigator]
START_DEPTH	[Supplied by Investigator]
END_DEPTH	[Supplied by Investigator]
BULK_DENSITY	[Supplied by Investigator]
TOTAL_SOIL_C_CONTENT	[Supplied by Investigator]
SOIL_ORG_C_CONTENT	[Supplied by Investigator]
SOIL_INORG_C_CONTENT	[Supplied by Investigator]
CATION_EX_CAPACITY	[Supplied by Investigator]
EXCHANGE_SODIUM	[Supplied by Investigator]
EXCHANGE_POTASSIUM	[Supplied by Investigator]
EXCHANGE_CALCIUM	[Supplied by Investigator]
EXCHANGE_MAGNESIUM	[Supplied by Investigator]
WATER_CONTENT_10KPA	[Supplied by Investigator]
WATER_CONTENT_33KPA	[Supplied by Investigator]
WATER_CONTENT_1500KPA	[Supplied by Investigator]
SOIL_NITROGEN_CONTENT	[Supplied by Investigator]
SOIL_PHOSPHORUS_CONTENT	[Supplied by Investigator]
VERY_COARSE_SAND	[Supplied by Investigator]
COARSE_SAND	[Supplied by Investigator]
MEDIUM_SAND	[Supplied by Investigator]
FINE_SAND	[Supplied by Investigator]
VERY_FINE_SAND	[Supplied by Investigator]
TOTAL_SAND	[Supplied by Investigator]
TOTAL_SILT	[Supplied by Investigator]
TOTAL_CLAY	[Supplied by Investigator]
SOIL_TEXTURE	[Supplied by Investigator]
HORIZON_NUM	[Supplied by Investigator]
MINRL_SOIL_AND_CACL2_PH	[Supplied by Investigator]
ORG_SOIL_AND_CACL2_PH	[Supplied by Investigator]
MINRL_SOIL_AND_H2O_PH	[Supplied by Investigator]
ORG_SOIL_AND_H2O_PH	[Supplied by Investigator]
SOIL_EXTRACT_ACIDITY	[Supplied by Investigator]
SOIL_SULFUR_CONTENT	[Supplied by Investigator]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-9BS-9TETR	NSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE20-SOL01	9TE20-SOL09	None	None	None	None
MEASUREMENT_YEAR	1994	1994	None	None	None	None
PIT	1	9	None	None	None	None
HORIZON	2AE	OMZ4	None	None	None	None
START_DEPTH	-65	495	None	None	None	Blank
END_DEPTH	-34	495	-999	None	None	Blank
BULK_DENSITY	0	1640	-999	None	None	None
TOTAL_SOIL_C_CONTENT	.03	50.46	None	None	None	None
SOIL_ORG_C_CONTENT	0	50.46	None	None	None	None
SOIL_INORG_C_CONTENT	0	29.96	None	None	None	None
CATION_EX_CAPACITY	.5	193.5	-999	None	None	None
EXCHANGE_SODIUM	0	.4	-999	None	None	None
EXCHANGE_POTASSIUM	0	2.8	-999	None	None	None
EXCHANGE_CALCIUM	0	160.9	-999	None	None	None
EXCHANGE_MAGNESIUM	0	25.6	-999	None	None	None
WATER_CONTENT_10KPA	0	763.3	None	None	None	None
WATER_CONTENT_33KPA	0	289.3	-999	None	None	None
WATER_CONTENT_1500KPA	0	222.4	-999	None	None	None
SOIL_NITROGEN_CONTENT	.001	2.523	None	None	None	None
SOIL_PHOSPHORUS_CONTENT	0	0	None	None	None	None
VERY_COARSE_SAND	-.2	55.3	-999	None	None	Blank
COARSE_SAND	0	71.4	-999	None	None	None
MEDIUM_SAND	0	45.5	-999	None	None	None
FINE_SAND	0	79.8	-999	None	None	None
VERY_FINE_SAND	0	12.8	-999	None	None	None
TOTAL_SAND	0	99.7	-999	None	None	None
TOTAL_SILT	0	70.9	-999	None	None	None
TOTAL_CLAY	0	97.7	-999	None	None	None
SOIL_TEXTURE	N/A	N/A	None	None	None	Blank
HORIZON_NUM	01	13	None	None	None	None
MINRL_SOIL_AND_CACL2_PH	0	7.7	None	None	None	None
ORG_SOIL_AND_CACL2_PH	0	6.6	None	None	None	None
MINRL_SOIL_AND_H2O_PH	0	8.3	None	None	None	None
ORG_SOIL_AND_H2O_PH	0	7.1	None	None	None	None
SOIL_EXTRACT_ACIDITY	0	137.2	-999	None	None	None
SOIL_SULFUR_CONTENT	0	0	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	19-NOV-96	19-NOV-96	None	None	None	None

Minimum Data Value -- The minimum value found in the column.

```
Maximum Data Value -- The maximum value found in the column.
Missng Data Value  -- The value that indicates missing data. This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the attempt was unsuccessful.
Unrel Data Value   -- The value that indicates unreliable data.  This is used
                      to indicate an attempt was made to determine the
                      parameter value, but the value was deemed to be
                      unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the
                      instruments detection limits.  This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the analysis personnel determined
                      that the parameter value was below the detection
                      limit of the instrumentation.
Data Not Cllctd    -- This value indicates that no attempt was made to
                      determine the parameter value.  This usually
                      indicates that BORIS combined several similar but
                      not identical data sets into the same data base table
                      but this particular science team did not
                      measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A   -- Indicates that the value is not applicable to the respective column.
None  -- Indicates that no values of that sort were found in the column.
-------------------------------------------------------------------------------
```

7.4 Sample Data Record

The following are wrapped versions of data records from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,MEASUREMENT_YEAR,PIT,HORIZON,START_DEPTH,END_DEPTH,
BULK_DENSITY,TOTAL_SOIL_C_CONTENT,SOIL_ORG_C_CONTENT,SOIL_INORG_C_CONTENT,
CATION_EX_CAPACITY,EXCHANGE_SODIUM,EXCHANGE_POTASSIUM,EXCHANGE_CALCIUM,
EXCHANGE_MAGNESIUM,WATER_CONTENT_10KPA,WATER_CONTENT_33KPA,WATER_CONTENT_1500KPA,
SOIL_NITROGEN_CONTENT,SOIL_PHOSPHORUS_CONTENT,VERY_COARSE_SAND,COARSE_SAND,
MEDIUM_SAND,FINE_SAND,VERY_FINE_SAND,TOTAL_SAND,TOTAL_SILT,TOTAL_CLAY,
SOIL_TEXTURE,HORIZON_NUM,MINRL_SOIL_AND_CACL2_PH,ORG_SOIL_AND_CACL2_PH,
MINRL_SOIL_AND_H2O_PH,ORG_SOIL_AND_H2O_PH,SOIL_EXTRACT_ACIDITY,
SOIL_SULFUR_CONTENT,CRTFCN_CODE,REVISION_DATE
'NSA-9BS-9TETR','9TE20-SOL01','1994','1','CK',62.0,100.0,-999,22.73,.47,22.26,
19.4,.2,.4,19.4,3.1,41.9,35.9,21.4,.035,0.0,-999.0,-999.0,-999.0,-999.0,-999.0,
.6,34.4,65.0,'HC','08',7.6,0.0,8.3,0.0,0.0,0.0,'CPI',19-NOV-96
'NSA-9BS-9TETR','9TE20-SOL01','1994','1','L',-9.0,-7.0,50,32.16,32.16,0.0,-999.0,
-999.0,-999.0,-999.0,-999.0,0.0,-999.0,-999.0,.879,0.0,0.0,0.0,0.0,0.0,0.0,0.0,
0.0,0.0,'','01',0.0,6.0,0.0,6.5,-999.0,0.0,'CPI',19-NOV-96
```

8. Data Organization

8.1 Data Granularity

The smallest amount of data that can be ordered from this data set is the entire data set from all soil pits at the NSA sites.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

None given.

9.1.1 Derivation Techniques and Algorithms

Not applicable.

9.2 Data Processing Sequence

9.2.1 Processing Steps

None given.

9.2.2 Processing Changes

None given.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None given.

9.3.2 Calculated Variables

None.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

Most errors incurred would be due to the heterogeneity of soils and to equipment precision, all of which would be within the limits required for the use of these data.

10.2 Quality Assessment

The soil survey was performed by a soil expert who has many years of soil survey field experience. As a result, there is a great deal of confidence in the field visual observations and in the quality of soil samples brought into the lab for analysis. All methods for measuring soil characteristics have been performed routinely in the soil survey division of the Centre for Land and Biological Resources Research. All methods have been tested thoroughly for accuracy, accepted for the general soil survey of Saskatchewan, and approved at the federal research level.

10.2.1 Data Validation by Source
None given.

10.2.2 Confidence Level/Accuracy Judgment
See Section 10.2.

10.2.3 Measurement Error for Parameters
The error ranges for most of the parameters are as follows:

- pH: 5%
- Bulk Density: 5%
- TC and IC: 3%
- Total Nitrogen and Phosphorus: 5%
- EC and CEC: 5%
- Exchangeable H+: 10%
- Soil Moisture Retentions (0.3, 0.1, and 15 atm): 5%
- Particle Size Fractions: 5%

10.2.4 Additional Quality Assessments
None.

10.2.5 Data Verification by Data Center
A cursory review of the data was made to ensure that the data were as expected. Some spot checks were made to confirm that the data were within the realm of possibility. The data were checked after loading into the relational data base to ensure that no errors occurred during loading.

11. Notes

11.1 Limitations of the Data
None given.

11.2 Known Problems with the Data
None given.

11.3 Usage Guidance
None given.

11.4 Other Relevant Information
None.

12. Application of the Data Set

This data set was created for use by BOREAS investigators to use in ecological models and other research purposes.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description
None.

14.2 Software Access
None.

15. Data Access

The NSA soil lab data 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
None.

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

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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
CD-ROM	- Compact Disk-Read-Only Memory
CEC	- Cation Exchange Capacity
DAAC	- Distributed Active Archive Center
EC	- Electric Conductivity
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
GIS	- Geographic Information System
GSFC	- Goddard Space Flight Center
HTML	- HyperText Markup Language
IC	- Inorganic Carbon
MSA	- Modeling Sub-Area
NASA	- National Aeronautics and Space Administration
NIST	- National Institute of Standards and Technology
NSA	- Northern Study Area
OA	- Old Aspen
OBS	- Old Black Spruce
OC	- Organic Carbon
OJP	- Old Jack Pine
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
PI	- Principal Investigator
SSA	- Southern Study Area
TC	- Total Carbon
TE	- Terrestrial Ecology
TGB	- Trace Gas Biogeochemistry
URL	- Uniform Resource Locator
YJP	- Young Jack Pine

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13. ABSTRACT *(Maximum 200 words)*

This data set contains the major soil properties of soil samples collected in 1994 at the tower flux sites in the NSA. The soil samples were collected by Hugo Veldhuis and his staff from the University of Manitoba. The mineral soil samples were largely analyzed by Barry Goetz, under the supervision of Dr. Harold Rostad at the University of Saskatchewan. The organic soil samples were largely analyzed by Peter Haluschak, under the supervision of Hugo Veldhuis at the Centre for Land and Biological Resources Research in Winnipeg, Manitoba. During the course of field investigation and mapping, selected surface and subsurface soil samples were collected for laboratory analysis. These samples were used as benchmark references for specific soil attributes in general soil characterization. Detailed soil sampling, description, and laboratory analysis were performed on selected modal soils to provide examples of common soil physical and chemical characteristics in the study area. The soil properties that were determined include soil horizon; dry soil color; pH; bulk density; total, organic, and inorganic carbon; electric conductivity; cation exchange capacity; exchangeable sodium, potassium, calcium, magnesium, and hydrogen; water content at 0.01, 0.033, and 1.5 MPascals; nitrogen; phosphorus; particle size distribution; texture; pH of the mineral soil and of the organic soil; extractable acid; and sulfur. These data are stored in ASCII text files.

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