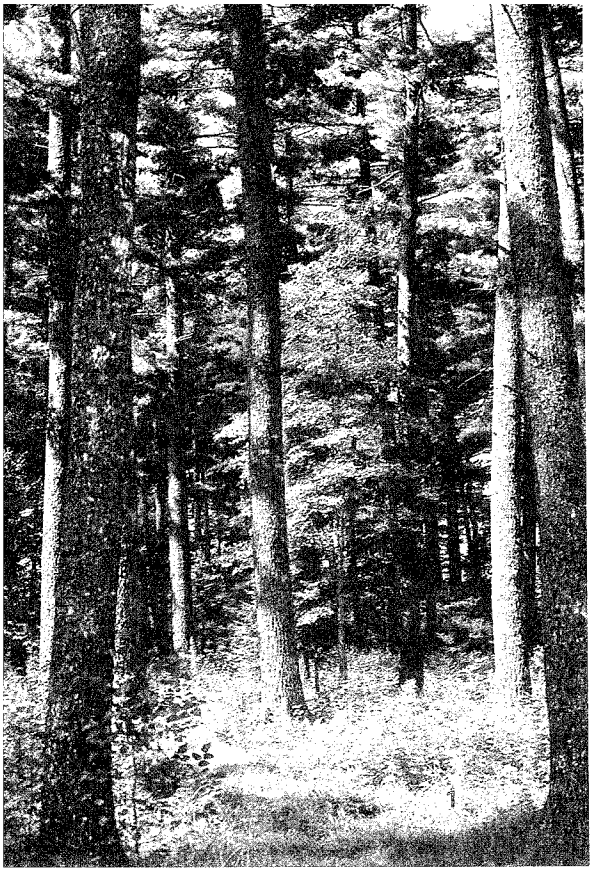
Miscellaneous Publication [illegible]

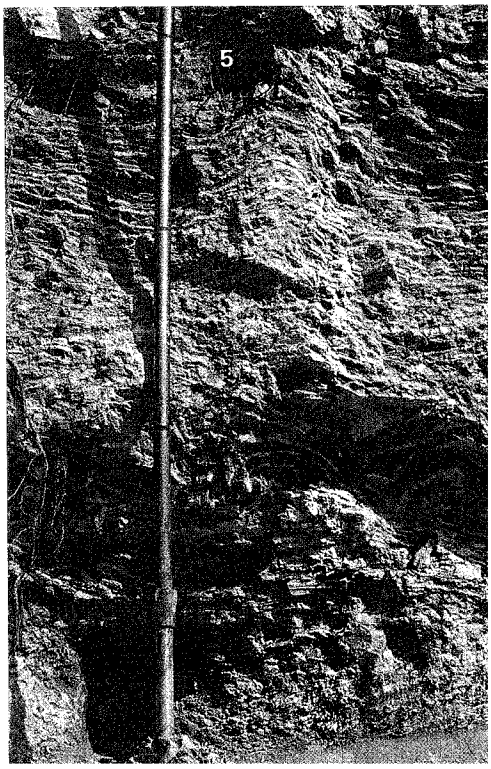
MINNESOTA SOIL ATLAS

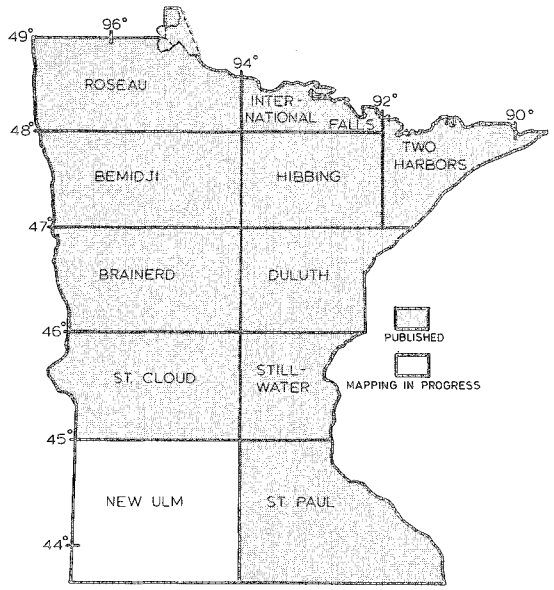
international falls-two harbors sheets

Agricultural Experiment Station
University of Minnesota



1. Virgin stands of white pine are a reminder of the early logging days in northeastern Minnesota. 2. Typical vegetation of peat bogs in soil landscape unit AP, Agassiz Lacustrine Plain, Big Fork Area (1B) and Agassiz Peatlands (1F). 3. Fall colors of tamarack trees growing in areas of organic soils. 4. Soil scientists describe and sample a site as part of the detailed soil survey of St. Louis County. 5. Lacustrine deposits in the Agassiz Lacustrine Plain, Big Fork Area (1B). The layers, called varves, mark annual accumulations of sediment.





Acknowledgement

The Department of Soil Science, University of Minnesota, in cooperation with the Soil Conservation Service, U.S. Department of Agriculture, and the Minnesota Geological Survey prepared this Minnesota Soils Atlas-International Falls and Two Harbors sheets, ninth and tenth in a series of eleven covering the entire state. Already published are the Brainerd Sheet, Miscellaneous Report 90, 1969 ($3); Hibbing Sheet, Miscellaneous Report 110, 1971 ($3); St. Paul Sheet, Miscellaneous Report 120, 1973 ($4); Metro Sheet, Miscellaneous Report 130, 1975 ($3); Duluth Sheet, Miscellaneous Report 148, 1977 ($4); St. Cloud Sheet, Miscellaneous Report 159, 1979 ($5); Bemidji Sheet, Miscellaneous Report 168, 1980 ($5); Stillwater Sheet, Miscellaneous Report 171, 1979 ($5); Roseau Sheet, Miscellaneous Report 173, 1980 ($5); and International Falls-Two Harbors Sheets, Miscellaneous Report 177, 1981 ($6).

R. A. Erickson, J. C. Harries, R. H. Rust, and R. L. Skarie did the field work, map, and report. H. E. Wright, Jr., Department of Geology, University of Minnesota, assisted in delineating the geomorphic areas. E. L. Kuehnast, state climatologist, prepared the section on climate.

The cooperation of the soil survey and district personnel of the Soil Conservation Service is gratefully acknowledged, as is the assistance of personnel of the Superior National Forest. Donald Prettyman, USDA Forest Service, Duluth, supplied soils information in the Crane Lake area and compiled information on the nature and extent of forest resources and forest potential.

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Introduction

Information is lacking on the soils and landscape characteristics of large areas of Minnesota. Many planning agencies simply have to go without information needed for their work. Detailed soil surveys published at a scale of 1:20,000 are being made by United States Department of Agriculture, Soil Conservation Service (USDA, SCS) in cooperation with the Minnesota Agricultural Experiment Station to fill this need, but because they cannot be supplied rapidly enough for broad planning, the Minnesota Soil Atlas has been developed. It is not intended to replace detailed soil survey reports, which are essential for planning the use of smaller land areas. Detailed soil survey information not yet available in published form has been gathered and supplemented with field work to compile the International Falls and the Two Harbors sheets of the Minnesota Soil Atlas.

Until detailed soil surveys are available for all Minnesota counties, broad planning can be facilitated by the eleven sheets published in Minnesota Soil Atlas series (see inside cover). As detailed soil surveys become available, the broad view of large planning areas will still be necessary. The maps of the series are published along with explanatory texts for each sheet in the state. For uniformity the atlas sheets are prepared at the same scale (1:250,000) as the U.S. Geological Survey topographic maps and other maps prepared by the Minnesota Geological Survey.

Use of the Soil Atlas

The Minnesota Soil Atlas provides essential information for broad planning. Some of the uses that can be developed from this map follow:

1. To determine areas suitable for various crops such as potatoes, sugar beets, and canning crops to enable processors to locate plants within areas of greatest potential.
2. To determine an area's potential for various types of farming, forestry, or recreation.
3. To determine areas that would benefit from drainage or irrigation.
4. To locate sources of sand and gravel.
5. To prepare wildlife density maps.

6. To locate pulp and lumber mills within areas of greatest potential supply.
7. To locate feasible routes for utility lines and highways.
8. To serve as a reference for science teachers in junior high, high school, and college courses.

For specific planning of individual farms, cities, towns, recreation areas, tax equalization, and road building purposes, more detailed surveys are necessary. However, this map may point to priority areas where detailed surveys will be most useful.

How the Maps Were Prepared

The base maps for the International Falls and Two Harbors sheets were prepared from the International Falls, Two Harbors, Thunder Bay, Hancock, Ashland, and Quetico quadrangles, published by the U.S. Geological Survey. The scale of 1:250,000 or about ¼ inch to 1 mile, makes it possible to show areas as small as 1 square mile. Contour intervals of 50 feet indicate some of the topography.

Four geomorphic areas are delineated in the International Falls sheet and 12 in the Two Harbors sheet to illustrate broad physiographic features and to provide identification as to the nature of parent materials in which the soils have developed (table 1). The terms geomorphic area and geomorphic region are used interchangeably in this report. Within the geomorphic areas soil landscape units are delineated. Tables 3 through 16 indicate which soil series (if known) are associated with the various soil landscape units. The same soil landscape unit occurring in two different geomorphic areas may contain different soil series.

Soil landscape delineations were developed from detailed soil surveys made by the USDA Soil Conservation Service where available. Field work was necessary where no detailed soil survey existed.

Table 1. Acreage estimates of geomorphic areas

International Falls Sheet

Geomorphic area number and name	Acres	Percent of sheet
1B Agassiz Lacustrine Plain, Big Fork Area	978,100	47.6
1F Agassiz Peatlands	138,300	6.7
18C Vermilion Moraine	4,700	0.2
19 Tower-Ely Glacial Drift and Bedrock Complex	932,200	45.4
Total for sheet	2,053,300	100.0

Two Harbors Sheet

Geomorphic area number and name	Acres	Percent of sheet
15 Toimi Drumlin Area, loamy	298,100	9.7
16 Mesabi Range, including mined areas	84,000	2.7
17 Big Rice Outwash Plain	3,600	0.1
17A Sawbill Outwash Plain	76,600	2.5
18B Big Rice Moraine	10,700	0.4
18C Vermilion Moraine	183,500	6.0
19 Tower-Ely Glacial Drift and Bedrock Complex	1,431,700	46.7
23 Brimson Outwash Plain, sandy	31,200	1.0
27 Allen Moraine	11,100	0.4
52A Highland Moraine, loamy, rolling to hilly	535,300	17.5
52B Highland Flutes, rocky, strongly sloping	327,400	10.7
53 Nemadji-Duluth Lacustrine Plain, clayey	69,700	2.3
Total for sheet	3,062,900	100.0

In the effort to provide a generalized map for the user with minimal soils knowledge, soils were grouped into landscape units based on the following factors:

1. Texture of the soil material deeper than 5 feet: sandy (S), loamy or silty (L), clayey (C), and bedrock (R).
2. Texture of the material less then 5 feet deep, or a significant part of it: sandy (S), loamy or silty (L), and clayey (C).
3. Drainage: Moderately well, well, and excessively drained designated (W); somewhat poorly, poorly, and very poorly drained designated (P). Units with (W) normally have water tables below the rooting zone, while units with (P), commonly have water tables within the rooting zone.
4. Color of surface soil: dark color (D), and light color (L).

The letters associated with each factor are combined to form symbols which designate the soil landscape units on the map. Some units have special one or two-letter symbols. All symbols used on the two sheets are listed and described in table 2.

The Two Harbors sheet encompasses approximately 3,062,900 acres in northeastern Minnesota, extending from the Canada-Minnesota border to south 47° north latitude and Lake Superior, and between 92° west longitude and Lake Superior. It includes all of Lake and Cook counties and the easternmost portion of St. Louis County.

The International Falls sheet encompasses approximately 2,053,300 acres in northeastern Minnesota, extending from 48° north latitude to the Canada-Minnesota border, and between 92° and 94° west longitude. This includes northern St. Louis County and the central and northeastern portions of Koochiching County.

The only detailed soil survey now available in published form is for the Kawishiwi Area in northern Lake and Cook counties. Detailed mapping of St. Louis County is underway and scheduled for completion in 1986.

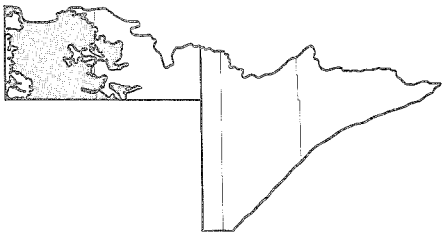
Table 2. Soil landscape units

International Falls Sheet

SSWL	—Sandy over sandy, well-drained, light-colored soils
SSPL	—Sandy over sandy, poorly drained, light-colored soils
LSWL	—Sandy over loamy, well-drained, light-colored soils
LSPL	—Sandy over loamy, poorly drained, light-colored soils
LLWL	—Loamy over loamy, well-drained, light-colored soils
LCPL	—Clayey over loamy, poorly drained, light-colored soils
CSPL	—Sandy over clayey, poorly drained, light-colored soils
CCWL	—Clayey over clayey, well-drained, light-colored soils
CCPL	—Clayey over clayey, poorly drained, light-colored soils
CCPD	—Clayey over clayey, poorly drained, dark-colored soils
RSWL	—Sandy over rock, well-drained, light-colored soils
RLWL	—Loamy over rock, well-drained, light-colored soils
AP	—Organic soils, acid
BP	—Organic soils, raised bog areas
NP	—Organic soils, non-acid
P	—Organic soils, undifferentiated
R	—Bedrock areas
A	—Alluvial soils

Two Harbors Sheet

AP	—Acid organic soils
CCWL	—Clayey over clayey, well-drained, light-colored soils
LLPL	—Deep silty or loamy, poorly drained, light-colored soils
LLWL	—Deep silty or loamy, well-drained, light-colored soils
NP	—Non-acid organic soils
P	—Organic soils, undifferentiated
R	—Bedrock
RCWL	—Clayey over rock, well-drained, light-colored soils
RLWL	—Silty or loamy over rock, well-drained, light-colored soils
RSWL	—Sandy over rock, well-drained, light-colored soils
SLWL	—Loamy over sandy, well-drained, light-colored soils
SSWL	—Sandy over sandy, well-drained, light-colored soils



1B Agassiz Lacustrine Plain, Big Fork Area

The Agassiz Lacustrine Plain, Big Fork Area encompasses approximately 978,100 acres or 47.6 percent of the International Falls sheet.

This plain is the northeastern part of the Beltrami Arm of Glacial Lake Agassiz. It is a nearly level to slightly depressed expanse of land locally interrupted by prominent bedrock outcrops and tributaries of the Rainy River. In well-drained soils the water table ranges from 3 to about 10 feet below the surface. In poorly drained soils the water table is usually less than 3 feet deep. Six lakes, each of 160 acres or more, totaling 41,200 acres are located in the region.

The soils are quite variable within short distances. Approximately 32 percent are organic, 43 percent are clayey, and 18 percent are sandy. About half of the sandy soils are underlain by clayey or loamy sediments within 2 to 4 feet of the surface. Poorly drained soils occupy about 79 percent of the region.

The peat ranges in thickness from a few to over 25 feet, and lake sediments are up to 5 feet or more thick. Sandy areas are lake laid or beach bar deposits. The underlying loamy glacial drift which fills the bedrock valley ranges from approximately 50 to 150 feet thick. In a few areas bedrock is within 10 feet of the surface.

The original vegetation was primarily black spruce and tamarack on the organic soils. White and red pine, upland spruce, and balsam fir occurred on the clayey soils, and jack pine on the sandy soils. Present forest consists mainly of trembling aspen, balsam fir, and some jack pine on the mineral soils, with black spruce, tamarack, and alder on the organic soils. An estimated 5 percent or less of the area is in pasture and crops. Oats is the main crop.

Seventeen soil landscape units are mapped in this geomorphic area. Table 3 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at end of this publication).

CCPL — The unit includes approximately 10 percent moderately well-drained and 5 percent very poorly drained soils. Organic soils occur in about 5 percent of the unit. In places, loamy sediments occur at depths of 2 to 4 feet. (Typic Ochraqualfs)

AP — Non-acid and shallow peat occurs in 20 to 30 percent of the unit, and another 5 to 10 percent are clayey mineral soils. (Typic Borohemists)

NP — Approximately 15 percent of this unit consists of shallow peat and 10 percent deep acid peat. Poorly drained clayey soils make up about 5 percent and poorly drained sandy soils occur in another 5 percent of the unit. (Typic Borohemists)

CCWL — Approximately 10 percent of the unit consists of poorly and very poorly drained soils. Included are small areas of shallow peat and shallow clayey over loamy soils. (Aquic Eutroboralfs)

CSPL — Ten to 20 percent of the unit consists of deep sandy soils. Included are small areas of well-drained sandy soils, shallow organic, and sandy over loamy soils. (Typic Haplaquents)

SSPL — This unit includes 10 to 15 percent moderately well-drained soils and 5 to 10 percent shallow sandy over clayey. Five to 10 percent are very poorly drained soils. Small areas of shallow peat are also included. (Typic Psammaquents)

SSWL — Approximately 10 percent is poorly drained. Small areas of shallow sandy over clayey and shallow peat over sand are also included. (Typic Udorthents)

LSPL — About 15 percent of these soils are very poorly drained. Also included are small areas of shallow sandy over clayey soils. Another 5 to 10 percent are moderately well-drained soils. (Typic Haplaquents)

P — These units occur along the border between this sheet and the Hibbing sheet. The acid and non-acid peats were not separated. This unit includes 15 to 25 percent shallow peat and less than 5 percent mineral soils. Of the remainder slightly over 50 percent is non-acid. (Typic Borohemists)

BP — Deep acid peat makes up approximately 15 percent of this unit. (Typic Sphagnofibrists)

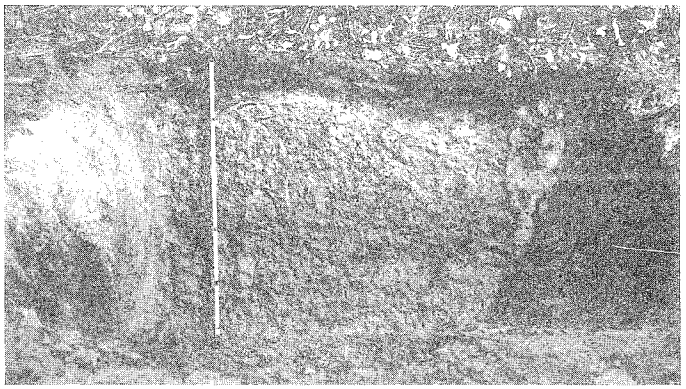
CCPD — Approximately 15 percent of the unit consists of shallow organic soils over clayey sediments. Another 15 percent are poorly drained light-colored clayey soils. (Histic Humaquepts)

LCPL — Deep clayey soils occupy 5 to 10 percent of the unit. Another 5 to 10 percent are moderately well-drained and about 5 percent are shallow organic soils. (Typic Ochraqualfs)

LSWL — Nearly level to slightly depressional, poorly drained areas occupy 25 to 35 percent of the unit. Deep sands occur in about 10 percent and peat soils in another 5 percent of the unit. (Aquic Udipsamments)

RLWL — This unit consists of outliers of geomorphic area 19 which occur within the lake plain. The soils commonly have fragipans which retard the downward movement of water. Included in the unit is about 10 percent deep loamy soils, 10 percent bedrock, and 5 percent clayey soils. (Typic Fragiochrepts)

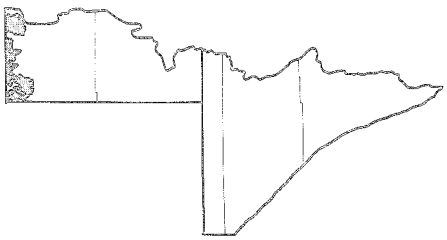
A, LLWL, and R — These are minor units within geomorphic area 1B.



Typical profile of soil landscape unit CCWL formed in clayey sediments of glacial Lake Agassiz.

Table 3. Selected features of soil landscape units within the Agassiz Lacustrine Plain, Big Fork Area (1B) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
CCPL	28	nearly level lake plain	silty clay or clay (3)	clay (3-20+)	8-12	poorly drained	5.2-6.2	high	medium	Indus
AP	16	level to depressional lake plain	peat (3)	peat (3+)	>12	very poorly drained	<5.5	low	low	Greenwood Unnamed
NP	15	level to depressional lake plain	peat (3)	peat (3+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake Seelyeville
CCWL	14	gently rolling lake plain	silty clay (3)	clay (3-20+)	8-12	moderately well drained	5.2-6.2	high	medium	Taylor Indus
CSPL	6	nearly level lake plain	loamy fine sand or fine sand (2-4)	clay (4-20+)	4-8	poorly drained	<6.0	medium	low	Unnamed
SSPL	5	nearly level lake plain	loamy fine sand or fine sand (1-3)	fine sand (3-20+)	<4	poorly drained	5.2-6.2	low to medium	low	Cormant Unnamed
SSWL	4	nearly level to gently rolling lake plain and beaches	loamy fine sand or fine sand (1-3)	fine sand (3-20+)	<4	somewhat poorly to moderately well drained	5.2-6.2	very high	low	Unnamed
LSPL	4	nearly level lake plain	loamy fine sand or fine sand (2-4)	loam or clay loam (4+)	4-8	poorly drained	5.2-6.2	high	low	Grygla Unnamed
P	1	level to depressional lake plain	peat (1-3)	peat (3+)	>12	very poorly drained	<7.0	low	low	Mooselake Greenwood Cathro Unnamed
BP	1	level to depressional lake plain	sphagnum peat (1-3)	peat (3+)	>12	very poorly drained	<5.5	low	low	Washkish Lobo
CCPD	1	nearly level lake plain	silty clay (3)	clay (3-20+)	8-12	very poorly drained	5.6-6.5	low	high	Wildwood
LCPL	1	nearly level lake plain	silty clay (2-4)	loam (4-20+)	8-12	poorly drained	5.2-6.2	low	low	Unnamed
LSWL	1	nearly level to undulating lake plain	loamy fine sand or fine sand (2-4)	loam or clay loam (4-20+)	4-8	moderately well drained	5.2-6.2	high	low	Unnamed
RLWL	<1	rolling to steep upland	gravelly sandy loam (0-3)	gravelly sandy loam or bedrock (3+)	<4	well drained	5.0-6.0	low	medium	Conic Insula
A	<1	nearly level narrow stream bottoms	silty clay to sandy loam (2-4)	silty clay to sandy loam (4+)	4-12	variable	<6.0	variable	variable	Unnamed
LLWL	<1	nearly level to gently rolling	silt loam (4)	silt loam (4+)	8-12	moderately well drained	5.5-6.5	high	medium	Baudette
R	<1	steep upland	loam, gravelly sandy loam or bedrock (0-2)	bedrock or gravelly sandy loam (2+)	<4	well drained	<6.0	low	medium	Quetico
Lakes	1									



1F Agassiz Peatlands

The Agassiz Peatlands have approximately 138,300 acres or 6.7 percent of the International Falls sheet.

This geomorphic area occurs primarily in the Roseau sheet with only the eastern part extending onto the International Falls sheet. The region is part of one of the largest continuous peat areas in the world. Located in the Beltrami Arm of Glacial Lake Agassiz, the area is low, level, and very poorly drained. Included are a few small sandy areas which are up to 3 feet higher in elevation than the peat soils. No lakes are located in the region. The water table is normally within 3 feet of the surface.

Most of the peat is more than 4 feet thick. Some areas are raised bogs which are topographically higher than the surrounding peatland as a result of rapid growth of sphagnum mosses, heather shrubs, and tamarack and black spruce trees. These species all tolerate a low supply of mineral nutrients. The sandy soils are 2 to 4 feet thick over loamy glacial till. The available water capacity is very high in the peat soils and low to very low in the sandy soils.

The original vegetation was tamarack and black spruce and the same is true today. Virtually none of the area is in pasture or cultivation.

Nine soil landscape units are mapped in this geomorphic area. Table 4 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

NP — Peat soils less than 4 feet thick occur in about 15 percent of the unit. Another 15 to 25 percent are acid peat soils. Less than 5 percent are poorly drained mineral soils. (Typic Borohemists)

AP — Approximately 15 percent of the unit are non-acid peats. Small areas of poorly drained sandy soils also are included. (Typic Borohemists)

BP — These are raised bogs and occur on slightly higher topographic positions. Small areas of acid peat (AP) are included. (Typic Sphagnofibrists)

SSPL — Small areas of shallow peat over sandy material are included with this unit. (Typic Psammaquents)

LSPL — The unit includes some shallow peat soils. (Typic Haplaquents)

CCPL — Soils in approximately 10 percent of this unit are moderately well drained, 5 to 10 percent are very poorly drained, and another 5 percent are shallow organic soils. (Typic Ochraqualfs)

A — This is a minor unit occurring along the West Fork Black River. (Unclassified)

LSWL — About 15 percent of this minor unit is poorly drained. Small areas of medium-textured soils also are included in this unit. (Aquic Udipsamments)

SSWL — This minor unit includes some poorly drained soils. (Spodic Udipsamments)

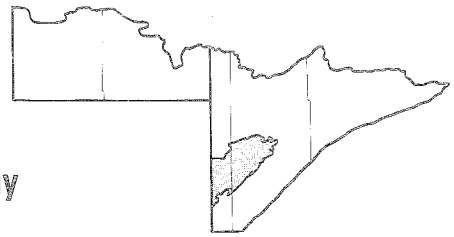
Table 4. Selected features of soil landscape units within the Agassiz Peatlands (1F) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
NP	51	level to depressional lake plain	peat (3)	peat (3-4+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake
AP	38	level to depressional lake plain	peat (3)	peat (3-4+)	>12	very poorly drained	<5.5	low	low	Greenwood Unnamed
BP	4	level to depressional lake plain	peat (3)	peat (3-5+)	>12	very poorly drained	<5.5	low	low	Washkish
SSPL	1	nearly level lake plain	loamy fine sand to fine sand (1-3)	fine sand (3-20+)	<4	poorly drained	5.2-6.2	low to medium	low	Cormant Unnamed
LSPL	1	nearly level lake plain	loamy fine sand to fine sand (2-4)	loam to clay loam (4+)	4-8	poorly drained	5.2-6.2	high	low	Grygla Unnamed

Table 4 (continued). Selected features of soil landscape units within the Agassiz Peatlands (1F) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
CCPL	1	nearly level lake plain	silty clay or clay (3)	clay (3-20+)	8-12	poorly drained	5.2-6.2	high	medium	Indus
A	<1	nearly level narrow stream bottoms	silty clay to sandy loam (2-4)	silty clay to sandy loam (4+)	4-12	variable	<6.0	variable	variable	Unnamed
LSWL	<1	nearly level to undulating lake plain	loamy fine sand or fine sand (2-4)	loam or clay loam (4-20+)	4-8	moderately well drained	5.2-6.2	high	low	Unnamed
SSWL	<1	nearly level to gently rolling lake plain	loamy fine sand to fine sand (1-3)	fine sand (3-20+)	<4	somewhat poorly to moderately well drained	5.2-6.2	very high	low	Unnamed

Black spruce trees are interspersed with sedge and reedgrass with vegetation in this peat bog, typical of the Agassiz Peatlands (1F).



15 Toimi Drumlin Area, loamy

The Toimi Drumlin Area encompasses about 298,100 acres or 9.7 percent of the Two Harbors sheet. It extends onto the Hibbing sheet.

The Toimi Drumlins are a group of northeast-southwest oriented ovoid hills, generally separated by peat bogs or poorly drained minerals soils. The regional drainage pattern is towards the southwest. The drumlins are about a mile long, ¼ mile wide, and 30 to 50 feet high. The water table on drumlins is normally more than 10 feet deep and on inter-drumlin areas it is usually within 6 feet at the surface. Seventeen lakes totaling 7,800 acres, each larger than 160 acres, are located in the region.

The drumlins consist of slightly acid, brownish loamy glacial till. Coarse fragments make up 20 to 30 percent of the material. Soils on the drumlins have low inherent fertility and low to moderate water-holding capacity.

The original forest was white and red pine, balsam fir, and spruce. An estimated 5 to 10 percent is presently cultivated. The main crops are oats, timothy, brome, and clover. Less than 5 percent is pasture and the rest is woodland. Trembling aspen, balsam fir, birch, and spruce are the dominant species.

Seven soil landscape units are mapped in this geomorphic area. Table 5 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at end of this publication).

LLWL — These soils have fragipans at depths below 14 to 28 inches. The unit contains about 30 percent organic soils, 10 percent poorly to very poorly drained soils, and small areas of sandy soils. (Typic Fragiochrepts)

NP — Approximately 30 percent of the unit consists of acid peat and shallow peat soils. Another 5 percent are poorly drained mineral soils. (Typic Borohemists)

SSWL — These soils are primarily shallow sandy loams over sand and gravel. The unit includes about 5 percent of somewhat poorly and poorly drained sandy soils. Approximately 15 percent of the unit is gravelly sandy loam till. (Typic Udorthents)

SLWL — Approximately 15 percent of this unit is poorly drained. Another 15 percent is sandy, and 5 percent is peat. (Glossic Eutroboralfs)

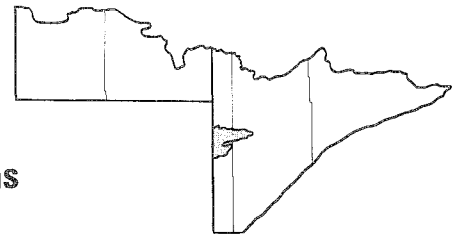
P — Acid and non-acid organic soils were not separated in this unit. The areas border the Hibbing sheet. Included are approximately 15 percent shallow peat soils and small areas of poorly drained mineral soils. (Typic Borohemists)

LLPL — The subsoils of this unit are compact. Included are moderately well-drained soils comprising about 15 percent of the unit. Peat makes up another 15 percent. (Aeric Fragiaqualfs)

RLWL — Approximately 10 percent of the unit consists of bedrock or shallow, gravelly sandy loam till less than 8 inches thick over bedrock. Deep, gravelly sandy loam till makes up another 10 percent. (Typic Dystrochrepts and Lithic Dystrochrepts)

Table 5. Selected features of soil landscape units within the Toimi Drumlin Area, loamy (15) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWL	46	prominent sloping drumlins and adjacent low lying areas	gravelly sandy loam and peat (2-4)	gravelly sandy loam (4-20+)	4-8	well drained and very poorly drained	4.8-5.5	low	medium	Newfound Mooselake Unnamed
NP	38	broad drainageways	peat (1-3)	peat (3+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake Unnamed
SSWL	6	eskers, outwash, and ice-contact glacial deposits, gently rolling	very gravelly loamy coarse sand and sandy loam (1-3)	very gravelly coarse sand (3-20+)	<4	excessively drained	5.2-6.2	very high	medium	Toivola Unnamed
SLWL	4	outwash plains, eskers, and kames, nearly level to hilly	sandy loam (1-3)	sand and gravel (3-20+)	4-8	well drained	5.5-6.1	high	medium	Unnamed
P	2	broad drainageways	peat (1-3)	peat (3+)	>12	very poorly drained	<7.0	low	low	Mooselake Greenwood Beseman
LLPL	1	low lying depressions and drainageways	gravelly sandy loam (2-4)	gravelly sandy loam (4-20+)	4-8	poorly and very poorly drained	5.0-5.5	low	low	Unnamed
RLWL	<1	rolling till plains, shallow to bedrock	gravelly sandy loam (0-3)	bedrock and gravelly sandy loam (3+)	0-8	well to excessively drained	5.0-6.0	medium	high	Mesaba Barto Newfound
Lakes	3									



16 Mesabi Range, including mined areas

The Mesabi Range covers approximately 84,000 acres or 2.7 percent of the Two Harbors sheet.

The region consists of gently rolling to steep, irregular topography intermixed with numerous peat bogs and outcrops of bedrock. Along the northern perimeter, slopes generally are steeper, more irregular, and have more outcrops of bedrock. A large open pit iron ore mine is located south of Babbitt. Normally the water table is more than 10 feet deep on higher positions and less than 6 feet deep on peat bogs and poorly drained soils. Where the glacial drift is shallow to bedrock the water table may be near the surface during wet periods. Two large lakes, totaling approximately 3,000 acres, are located in the region.

The dark brown, medium acid, gravelly sandy loam glacial till is generally 20 to 40 inches thick over bedrock. The till contains 15 to 25 percent gravel and cobbles. Available water capacity ranges from very low to moderate depending on depth to bedrock.

Red and white pine, balsam fir, and spruce comprised the original forest. Present forest consists of trembling aspen, balsam fir, and spruce. Virtually no land is under cultivation.

Nine soil landscape units are mapped in this geomorphic area. Table 6 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

RLWL — In approximately 25 percent of the unit, bedrock occurs 8 to 20 inches below the surface and less than 8 inches in another 10 percent. Small peat bogs and deeper soils make up about 15 percent of the unit. (Typic and Lythic Dystrochrepts)

LLWL — The subsoils of this unit have fragipans which deter the downward movement of water. This unit includes 10 to 20 percent poorly drained soils and small peat bogs. Glacial till is less than 40 inches thick over bedrock in another 15 to 20 percent and rock outcrops occur in about 15 percent of the unit. (Typic Fragiochrepts)

SSWL — The unit includes a few nearly level areas. Very little gravel occurs in about 20 percent of the unit. Loamy till makes up another 10 percent. About 10 percent of the unit consists of poorly drained soils and small peat bogs. (Typic Udorthents)

NP — Acid peats occur in 20 to 30 percent of the unit. Another 15 to 25 percent is shallow peat soils. Small areas of poorly drained mineral soils also are included. (Typic Borohemists)

P — These peat bogs border the Hibbing sheet and are not classified into acid and non-acid organic soils. An estimated 45 percent are non-acid, 40 percent are acid, 15 percent are shallow peats, and minor areas are mineral soils. (Typic Borohemists)

MD — The mine dumps are high, steep, and composed of various sized bedrock fragments inter-mixed with finer material. They are acid and very low in fertility. Since they are nearly devoid of vegetation, considerable erosion occurs in places. (Unclassified)

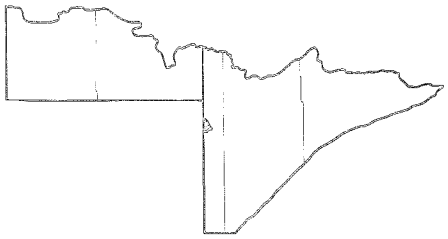
R — Bedrock outcrops in approximately 30 percent of the unit and is covered by 8 inches of till in another 10 percent. (Lithic Dystrochrepts)

RSWL — In this unit the glacial drift ranges from sandy to loamy. The unit borders with the Hibbing sheet. (Typic and Lithic Dystrochrepts)

LLPL — Inclusions are mainly small areas of moderately well-drained and very poorly drained soils. (Aeric Fragiaqualfs)

Table 6. Selected features of soil landscape units within the Mesabi Range, including mined areas, (16) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
RLWL	25	shallow drift over bedrock, rolling to steep	gravelly sandy loam (0-3)	bedrock and cobbly sandy loam (3+)	<8	well drained to excessively drained	5.0-6.0	medium	high	Mesaba Barto
LLWL	20	rolling to steep moraines	gravelly sandy loam (2-4)	gravelly sandy loam (4-20+)	4-8	well drained	4.8-5.5	low	medium	Newfound
SSWL	15	rolling ice-contact glacial deposits, eskers, and kames	gravelly coarse loamy sand (1-3)	gravelly coarse sand (3-20+)	<4	excessively drained	5.2-6.2	very high	medium	Toivola
NP	14	depressions	peat (1-3)	peat (3+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake Unnamed
P	8	low lying depressions	peat (1-3)	peat (3+)	>12	very poorly drained	<7.0	low	low	Mooselake Greenwood Beseman
MD	7	deep pit iron ore mines and dumps								
R	5	bedrock and shallow till	gravelly sandy loam and bedrock (0-2)	bedrock and gravelly sandy loam (2+)	<4	well to excessively drained	5.0-6.0	medium	high	Quetico Insula Barto
RSWL	2	rolling to steep moraines and glacial drift, shallow to bedrock	gravelly loamy sand and gravelly sandy loam (0-4)	cobbly loamy sand, bedrock, and cobbly sandy loam (4+)	<8	well drained	5.0-6.0	medium	high	Unnamed Mesaba Barto Quetico Newfound
LLPL	1	low lying depressions and drainageways	gravelly sandy loam (2-4)	gravelly sandy loam (4-20+)	4-8	somewhat poorly and poorly drained	5.0-5.5	low	low	Unnamed
Lakes	3									



17 Big Rice Outwash Plain

The Big Rice Outwash Plain encloses approximately 3,600 acres or 0.1 percent of the Two Harbors sheet.

The region consists of a nearly level to gently rolling plain which includes a relatively large peat bog. Most of this region is located in the Hibbing sheet. The water table is normally more than 6 feet deep on well-drained sandy soils and less than 3 feet deep on peat bogs. There are no lakes larger than 160 acres.

Soils of the region are medium to strongly acid, sandy, and in places quite gravelly. The available water capacity is generally very low.

The original forest consisted of jack pine, balsam fir, and spruce. An estimated 40 to 50 percent is presently meadow, and 50 to 60 percent is forest consisting mainly of jack pine and trembling aspen.

Two soil landscape units are mapped in this geomorphic area. Table 7 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

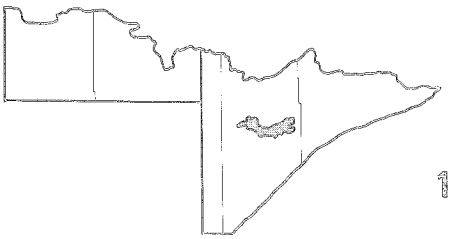
SSWL — Minor inclusions of poorly drained soils and well-drained loamy soils occur in the unit. (Typic Udorthents)

P — In this unit acid and non-acid organic soils were not separated. About 10 percent of the unit is shallow peat soils. (Typic Borohemists)

Table 7. Selected features of soil landscape units within the Big Rice Outwash Plain (17) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
SSWL	70	nearly level to gently rolling outwash plain	gravelly coarse loamy sand and loamy sand (1-3)	gravelly coarse sand (3-20+)	<4	excessively drained	5.0-6.0	very high	low	Toivola Omega Unnamed
P	27	depressions	peat (1-3)	peat (3+)	>12	very poorly drained	<7.0	low	low	Mooselake Dawson Greenwood
Lakes	3									

Jack pines thrive on the excessively drained soils of soil landscape unit SSWL in the Big Rice Outwash Plain (17) and the Sawbill Outwash Plain (17A).



17A Sawbill Outwash Plain

The Sawbill Outwash Plain encompasses approximately 76,600 acres or about 2.5 percent of the Two Harbors sheet.

Topography in this geomorphic area ranges from gently sloping to rolling. Numerous peat bogs occur in the region, several of which are relatively large. Five lakes, each larger than 160 acres and totaling 2,300 acres, occur in the Sawbill Outwash Plain. Depth to the water table is normally more than 10 feet. In the peat bogs, water tables are less than 3 feet deep.

The soils are dark brown, medium acid, and sandy. Cobbles and gravel make up 50 to 90 percent of the material.The available water capacity of these soils is very low.

The original forest consisted of balsam fir, jack, red, and some white pine. Present forest is mainly trembling aspen, balsam fir, and jack pine. Virtually no land in the region is under cultivation.

Three soil landscape units are mapped in this geomorphic area. Table 8 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

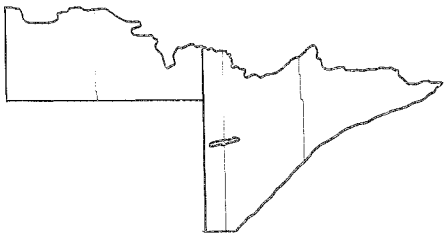
SSWL — The unnamed soils include about 40 percent of the unit. They are mostly sandy and gravelly soils but include some shallow sandy loams over sand and gravel. Approximately 10 percent are somewhat poorly and poorly drained. Organic soils comprise about 10 percent of the unit. (Typic Udorthents)

NP — Acid peat soils make up about 20 percent and shallow peat over sand occurs in another 20 percent of the unit. Sandy and gravelly outwash comprises another 10 percent. (Typic Borohemists)

LLWL — The soils have fragipans which retard the downward movement of water. Approximately 20 percent are sandy and gravelly soils. Poorly drained mineral soils and peat make up an additional 10 percent of the unit. (Typic Fragiochrepts)

Table 8. Selected features of soil landscape units within the Sawbill Outwash Plain (17A) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
SSWL	80	gently rolling to rolling outwash plain	gravelly coarse loamy sand to loamy sand (1-3)	gravelly coarse sand (3-20+)	<4	excessively drained	5.2-6.2	very high	medium	Toivola Unnamed
NP	16	depressions	peat (1-3)	peat (3+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake Dawson Unnamed
LLWL	1	gently rolling to rolling till	gravelly sandy loam and sandy loam (2-4)	gravelly sandy loam and sandy loam (4-20+)	4-8	well drained	4.8-5.5	low	medium	Newfound
Lakes	3									



18B Big Rice Moraine

The Big Rice Moraine encompasses approximately 10,700 acres or 0.4 percent of the Two Harbors sheet.

This is a narrow moraine, generally about ½ mile wide with rolling to steep topography. Bedrock is more than 40 inches deep over most of the region, but outcrops in several places. Peat bogs dissect the moraine in two places and extend into geomorphic areas to the north and south. There are no lakes larger then 160 acres in the moraine. The water table is normally more than 10 feet deep in well-drained soils and less than 3 feet deep in organic soils. Where glacial drift is shallow over bedrock the water table may be near the surface during wet periods.

The soil material consists of gravelly and sandy glacial ice-contact deposits on the eastern end and glacial till on the western end. The available water capacity ranges from low to moderate.

Originally the forest was made up of red and white pine, balsam fir, and spruce. Trembling aspen, balsam fir, and spruce are the main species today. Virtually no land is under cultivation.

Four soil landscape units are mapped in this geomorphic area. Table 9 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

SSWL — Glacial till occurs in about 10 percent of the unit. In another 10 percent bedrock occurs within 20 inches of the surface. (Typic Udorthents)

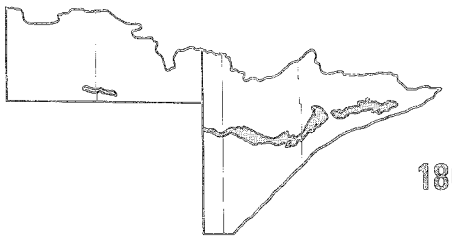
NP — An estimated 10 to 15 percent of the unit includes mineral soils. Another 15 to 20 percent are acid organic soils. (Typic Borohemists)

RLWL — Bedrock either outcrops, or is within 8 inches of the surface in about 10 percent of the unit and is more than 40 inches deep in another 10 percent. The unit includes small areas of peat. (Typic Dystrochrepts and Lithic Dystrochrepts)

LLWL — The soils have fragipans at depths below 14 to 28 inches which retard the downward movement of water. Approximately 20 percent of the unit includes soils less than 40 inches thick over bedrock. About 10 percent are sandy and gravelly. (Typic Fragiochrepts)

Table 9. Selected features of soil landscape units within the Big Rice Moraine (18B) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
SSWL	40	rolling to steep moraine, ice-contact glacial deposits	very gravelly loamy sand and loamy sand (1-3)	very gravelly coarse sand and sand (3-20+)	<4	excessively drained	5.0-6.0	very high	low	Toivola Unnamed
NP	26	depressions	peat (1-3)	peat (3+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake Unnamed
RLWL	22	rolling to steep moraine, shallow drift over bedrock	gravelly sandy loam (0-3)	gravelly sandy loam and bedrock (3+)	<8	well drained to excessively drained	5.0-6.0	medium	high	Mesaba Barto
LLWL	11	rolling to steep moraine	gravelly sandy loam (4)	gravelly sandy loam (4-20+)	4-8	well drained	4.8-5.5	low	medium	Newfound
Lakes	<1									



18C Vermilion Moraine

The Vermilion Moraine encompasses approximately 183,500 acres or 6.0 percent of the Two Harbors sheet and about 4,700 acres or 0.2 percent of the International Falls sheet.

This geomorphic area is a prominent moraine of the Rainy Lobe, varying from 0.5 to 4 miles wide and an estimated 50 to 100 feet above the surrounding area. Some peat bogs and outcrops of bedrock occur throughout the region. The water table is generally 10 feet or more below the surface in the higher areas. In low areas it occurs at depths less than 6 feet.

Nine lakes, each larger than 160 acres and totaling about 6,100 acres, occur in the Two Harbors portion of the region. No lakes are located in the International Falls portion.

The soils are developed in glacial ice-contact sandy sediments and glacial till. All the mineral soils contain a high percent of gravel and cobbles. Depth to bedrock may range from zero to more than 20 feet. The available water capacity ranges from very low to moderate.

The original vegetation was white and red pine, balsam fir, and spruce. Today's forest is trembling aspen, balsam fir, spruce, and some jack and red pine. Less than 5 percent is in pasture and meadow.

Five soil landscape units are mapped in this geomorphic area. Table 10 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

SSWL — The unit includes soils derived from glacial till in 10 to 20 percent of the unit and peat bogs in another 5 to 10 percent of the unit. (Typic Udorthents)

LLWL — Soils of the unit have fragipans which slow the downward movement of water. Approximately 15 percent of the unit is underlain by bedrock at less than 40 inches below the surface. Ten to 20 percent of the unit consists of sandy and gravelly soils and about 10 percent is peat bogs and poorly drained depressions. (Typic Fragiochrepts)

NP — Included is 5 to 10 percent of poorly to well-drained mineral soils, about 10 percent deep acid peat, and 10 percent shallow peat. (Typic Borohemists)

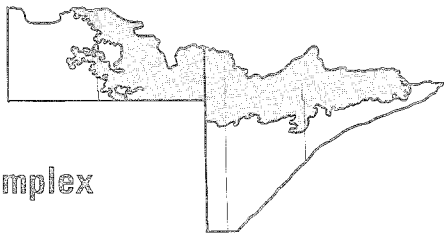
RLWL — Bedrock is within 20 inches of the surface in 35 to 45 percent of the unit and 20 to 40 inches in another 40 to 50 percent. Five to 15 percent of the unit consists of soils more than 40 inches thick over bedrock. The unit also includes a few small peat bogs. (Typic Udorthents)

SLWL — Approximately 15 percent of this unit is poorly drained, 15 percent is sandy at the surface, and 5 percent is peat. (Glossic Eutroboralfs)

Table 10. Selected features of soil landscape units within the Vermilion Moraine (18C) geomorphic area

Soil landscape unit	Percent geomorphic area TH[1]	IF[2]	Landscape position	Most common texture and thickness (feet) Rooting zone	Substratum	Moisture relationships Inches of available water to 5 feet	Drainage class	Approximate fertility in rooting zone pH	P	K	Representative soil series
SSWL	61	0	rolling to steep moraine, ice-contact glacial deposits	very gravelly loamy sand and gravelly sandy loam (1-3)	very gravelly coarse sand (3-20+)	<4	excessively drained	5.2-6.2	very high	medium	Toivola Unnamed
LLWL	20	100	rolling to steep moraine	gravelly sandy loam (4)	gravelly sandy loam (4-20+)	4-8	well drained	4.8-5.5	low	medium	Newfound
NP	11	0	depressions	peat (1-3)	peat (3+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake Unnamed
RLWL	3	0	rolling to steep moraine	gravelly sandy loam (0-3)	gravelly sandy loam and bedrock (3+)	<8	well drained	5.0-6.3	low	medium	Conic Insula Newfound
SLWL	<1	0	nearly level to hilly outwash plain, eskers and kames	sandy loam (1-2)	sand and gravel (2+)	4-8	well drained	5.5-6.1	high	medium	Unnamed
Lakes	4	0									

[1]Two Harbors sheet
[2]International Falls sheet



19 Tower-Ely Glacial Drift and Bedrock Complex

The Tower-Ely Glacial Drift and Bedrock Complex unit encompasses approximately 1,431,700 acres or 46.7 percent of the Two Harbors sheet and 932,200 acres or 45.4 percent of the International Falls sheet.

The topography is dominantly rolling with irregular slopes and some craggy outcrops of bedrock. Numerous long, narrow peat bogs occur in this sparsely settled region. Most of the Boundary Waters Canoe Area is located along its northern border.

The glacial ice sheet moving from west to east deepened the pre-existing stream valleys in the bedrock structure in north central Cook County. The valleys now contain the long narrow, east-west oriented lakes that are characteristic of the region. West of this region the lakes are generally more irregularly shaped. About 252 lakes, each larger than 160 acres, are located in the Two Harbors sheet. The total water area is about 187,800 acres. The International Falls sheet region contains 72 lakes totaling approximately 122,300 acres. Some lakes extend onto adjoining sheets. An additional 28 lakes occur along the border with Ontario, Canada. Normally the water table is deeper than 10 feet on the well-drained upland, but where the bedrock is shallow, water may be near the surface during wet periods. On the peat bogs the water table is normally less than 3 feet deep.

A mantle of brown, acid, cobbly and gravelly glacial till covers most of the bedrock. Pockets of cobbly, gravelly sand are intermixed with the till. Several relatively large sandy outwash and ice-contact areas occur in the region. The available water capacity of most soils in the region ranges from very low to moderate.

The original vegetation was dominantly red and white pine, spruce, and balsam fir. Present cover consists mainly of trembling aspen, red pine, birch, and spruce. Virtually no land is under cultivation.

Twelve soil landscape units are mapped in this geomorphic area. Table 11 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from most soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

RLWL — Bedrock occurs at depths of less than 8 inches in approximately 10 percent of the unit. Deeper till and sandy areas and small peat bogs make up another 10 percent of the unit. (Typic Dystrochrepts in the south and Typic Fragiochrepts in the north)

NP — Approximately 30 percent of the unit has acid peat soils. Another 10 percent has shallow organic soils. Mineral soils make up about 5 percent of the unit. (Typic Borohemists)

SSWL — This unit includes about 10 percent somewhat poorly and poorly drained gravelly and loamy outwash soils. Till, underlain by bedrock at 8 to 40 inches, occurs in 15 percent and organic soils in another 10 percent of the unit. (Typic Udorthents)

LLWL — Soils of the unit have fragipans which slow the downward movement of water. Approximately 15 percent of the unit has 20 to 40 inches of glacial till over bedrock. Bedrock is less than 20 inches below the till in another 5 percent. Organic soils and poorly drained mineral soils occur in about 15 percent of the unit. (Typic Fragiochrepts)

R — Depth to bedrock is more than 20 inches in 10 to 15 percent of the unit and bedrock outcrops in another 30 percent. (Lithic Dystrochrepts)

RSWL — Much of the glacial drift in this unit is slightly coarser textured than in unit RLWL. Soils in about 40 percent of the unit are 8-20 inches thick over bedrock, and less than 8 inches thick in another 10 percent. Bedrock outcrops in about 5 percent of the unit. (Typic Dystrochrepts in the south and Typic Fragiochrepts in the north)

AP — Non-acid peat occurs in about 20 percent of the unit. Shallow peat occupies another 10 percent, and 5 percent of the unit consists of wet mineral soils. (Typic Borohemists)

MD — This is a minor unit.

CCWL — Bedrock occurs within 40 inches of the surface in 5 to 10 percent of the unit and poorly drained soils occupy an additional 20 to 30 percent. Small areas of organic soils also are included. (Aquic Eutroboralfs)

CCPL — Dark-colored, very poorly drained soils occupy about 15 percent of the unit. Approximately 10 percent are moderately well-drained gently rolling areas. The unit includes about 5 percent peat. (Typic Ochraqualfs)

P — In this unit the acid and non-acid peat areas are not separated. These areas border the Hibbing sheet.

A — This is a minor unit.

Outcrops of granite bedrock are common throughout the Tower-Ely Glacial Drift and Bedrock Complex (19).

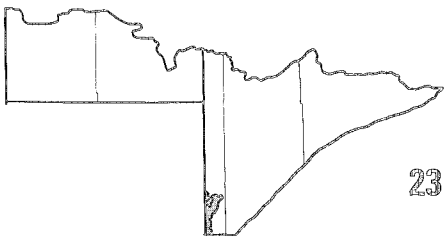
Table 11. Selected features of soil landscape units within the Tower-Ely Glacial Drift and Bedrock Complex (19) geomorphic area

Soil landscape unit	Percent geomorphic area TH[1]	IF[2]	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
				Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
RLWL	77	75	shallow drift over bedrock, rolling to steep	gravelly sandy loam, cobbly sandy loam and gravelly loamy sand (0-2)	bedrock, cobbly sandy loam and gravelly sandy loam (2+)	<8	well to excessively drained	5.0-6.0	low	medium	Mesaba Conic, Barto Insula Quetico Newfound
NP	4	5	low lying depressions	peat (1-3)	peat (3+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake Unnamed
SSWL	2	1	rolling to hilly eskers and ice-contact glacial deposits	very gravelly coarse sandy loam and gravelly loamy sand (1-3)	sand and gravel (3-20+)	<4	excessively drained	5.2-6.2	very high	medium	Toivola Unnamed
LLWL	2	0	rolling to hilly upland	gravelly sandy loam (2-4)	gravelly sandy loam (4-20+)	4-8	well drained	4.8-5.5	low	medium	Newfound

Table 11 (continued). Selected features of soil landscape units within the Tower-Ely Glacial Drift and Bedrock Complex (19) geomorphic area

Soil landscape unit	Percent geomorphic area TH[1]	IF[2]	Landscape position	Most common texture and thickness (feet) Rooting zone	Substratum	Moisture relationships Inches of available water to 5 feet	Drainage class	Approximate fertility in rooting zone pH	P	K	Representative soil series
R	1	<1	bedrock and very shallow drift over bedrock, steep	gravelly sandy loam, gravelly loamy sand and bedrock (0-2)	bedrock and gravelly sandy loam (2+)	<4	well to excessively drained	5.0-6.0	low	medium	Quetico Insula Barto
RSWL	1	2	shallow drift over bedrock, rolling to steep	gravelly loamy sand, and gravelly sand loam with cobbles (0-2)	bedrock, gravelly sandy loam and gravelly loamy sand (2+)	<8	well to excessively drained	5.0-6.0	low	medium	Mesaba Conic, Barto Insula Newfound Unnamed
AP	<1	<1	low lying depressions	peat (1-3)	peat (3+)	>12	very poorly drained	<5.5	low	low	Greenwood Unnamed
MD	<1	0	deep iron ore mines and dumps								
CCWL	0	3	gently sloping to rolling upland valleys	silty clay (3)	clay (3-20+)	8-12	moderately well drained	5.2-6.2	high	medium	Taylor Indus
CCPL	0	1	nearly level upland valleys	silty clay (3)	clay (3-20+)	8-12	poorly drained	5.2-6.2	high	medium	Indus
P	0	<1	low lying depressions	peat (1-3)	peat (3+)	>12	very poorly drained	<7.0	low	low	Mooselake Greenwood Beseman
A	0	<1	nearly level narrow stream bottoms	loam or sandy loam (2-4)	loam or sandy loam (4+)	4-12	variable	<6.0	variable	variable	Unnamed
Lakes	13	12									

[1]Two Harbors sheet
[2]International Falls sheet



23 Brimson Outwash Plain, sandy

The Brimson Outwash Plain contains approximately 31,200 acres or 1.0 percent of the Two Harbors sheet.

This geomorphic area ranges from nearly level to undulating, but includes steeper slopes bordering the Cloquet River. Small and medium-sized bogs are fairly common. The water table is normally deeper than 6 feet on the sandy plain and less than 3 feet deep on organic soils. Two lakes, each 160 acres or more in size, are located in the region. Water area totals 800 acres.

Most soils in the region are sandy, underlain by sand and gravel. Some areas contain very little gravel in the substrata. The available water capacity of these soils is very low.

The original vegetation was mainly upland spruce and balsam fir. Over 90 percent of the region is forested, largely by trembling aspen, balsam fir, spruce, and jack pine. Less than 10 percent is farmed; most is in pasture with some oats.

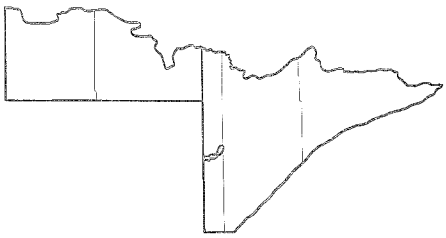
Two soil landscape units are mapped in this geomorphic area. Table 12 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

SSWL — An estimated 10 percent of the soils are in glacial till areas and 5 percent are shallow peat over sand. Minor areas of shallow loam over sand are also included. (Typic Udorthents)

NP — This unit includes 20 to 25 percent acid peat and 10 to 15 percent shallow peat over sand. Minor areas of sandy soils also occur. (Typic Borohemists)

Table 12. Selected features of soil landscape units within the Brimson Outwash Plain, sandy (23) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
SSWL	87	nearly level to undulating outwash plain	gravelly loamy sand, sandy loam and loamy sand (1-3)	gravelly coarse sand and sand (3-20+)	<4	excessively drained	5.2-6.2	very high	medium	Toivola Cloquet Unnamed
NP	10	depressional	peat (1-3)	peat (3+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake Unnamed
Lakes	3									



27 Allen Moraine

The Allen Moraine embraces approximately 11,100 acres or 0.4 percent of the Two Harbors sheet.

This elongated region is composed of rolling to steep, irregular topography about 40 to 80 feet above the elevation of the Toimi Drumlin Area (15). Wet depressions and small peat bogs are common. The water table is generally more than 10 feet below the surface. One lake is located in the region. Total water area is 800 acres.

The loamy till is brown, acid, cobbly, and stony, and is intermixed with a few pockets of sand and gravel. Bedrock outcrops in a few places, but is generally 5 to 20 feet below the surface. Over most of the region the available water capacity ranges from low to moderate.

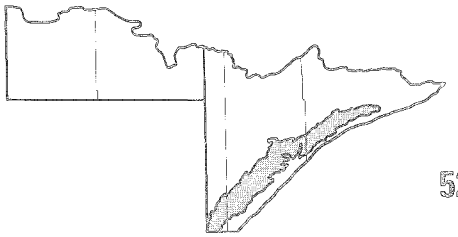
Originally white and red pine, spruce, and balsam fir covered the moraine. Present vegetation is trembling aspen, balsam fir, and spruce. Virtually none of the area is under cultivation.

One soil landscape unit is mapped in this geomorphic area. Table 13 lists the principal characteristics of the unit. The following paragraph further describes the unit and lists inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

LLWL — The soils have fragipans which retard the downward movement of water. Bedrock is less than 40 inches below the surface in about 10 percent of the unit and sandy gravelly soils occur in another 5 percent. Five to 10 percent of the soils are poorly drained and about 5 percent are organic. (Typic Fragiochrepts)

Table 13. Selected features of soil landscape units within the Allen Moraine (27) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWL	93	rolling to steep moraine	gravelly sandy loam (2-4)	gravelly sandy loam (4-20+)	4-8	well drained	4.8-5.5	low	medium	Newfound
Lakes	7									



52A Highland Moraine, loamy, rolling to hilly

The Highland Moraine covers approximately 535,300 acres or 17.5 percent of the Two Harbors sheet.

The topography of the moraine is rolling to hilly with numerous bedrock outcrops. Viewed from the east it is very prominent, ranging in elevation from 800 to 1,500 feet above Lake Superior. From the west it is much less prominent. Small peat bogs and wet depressions are numerous. In well-drained soils the water table is normally deeper than 10 feet. In peat bogs and poorly drained depressions it is usually less than 6 feet deep. Seventeen lakes, each larger than 160 acres and totaling 10,000 acres, are located in the Highland Moraine.

Throughout most of the moraine, a mantle of reddish brown, strongly acid, loamy till which is 20 feet or more in thickness overlies bedrock. Outcrops of bedrock occur mainly bordering the Highland Flutes (52B) region. Small areas of sandy and gravelly soils are included in this geomorphic area. The available water capacity of most soils is moderate.

The original forest was white and red pine, balsam fir, and spruce. Present forest consists mainly of trembling aspen, balsam fir, and birch. Very little land is pastured or cultivated.

Five soil landscape units are mapped in the geomorphic area. Table 14 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

LLWL — Soils having no fragipan characteristics occupy about 10 percent of the unit. Somewhat poorly and poorly drained soils occur in approximately 15 percent of the unit. Another 5 to 10 percent is composed of organic soils. Bedrock occurs at less than 40 inches below the surface in about 10 percent of the unit. (Typic Fragiochrepts)

SSWL — Gravelly loamy till occurs in approximately 15 percent of the unit. Shallow loam over sand and gravel occupies 10 to 15 percent of the unit, and organic soils occur in another 5 to 10 percent. (Typic Udorthents)

NP — Acid organic soils comprise an estimated 20 percent of the unit, and shallow peat over loamy soils make up another 10 percent. Approximately 5 percent are mineral soils. (Typic Borohemists)

SLWL — Approximately 15 percent of this unit has poorly drained soils, 15 percent has sandy soils, and 5 percent has peat soils. (Glossic Eutroboralfs)

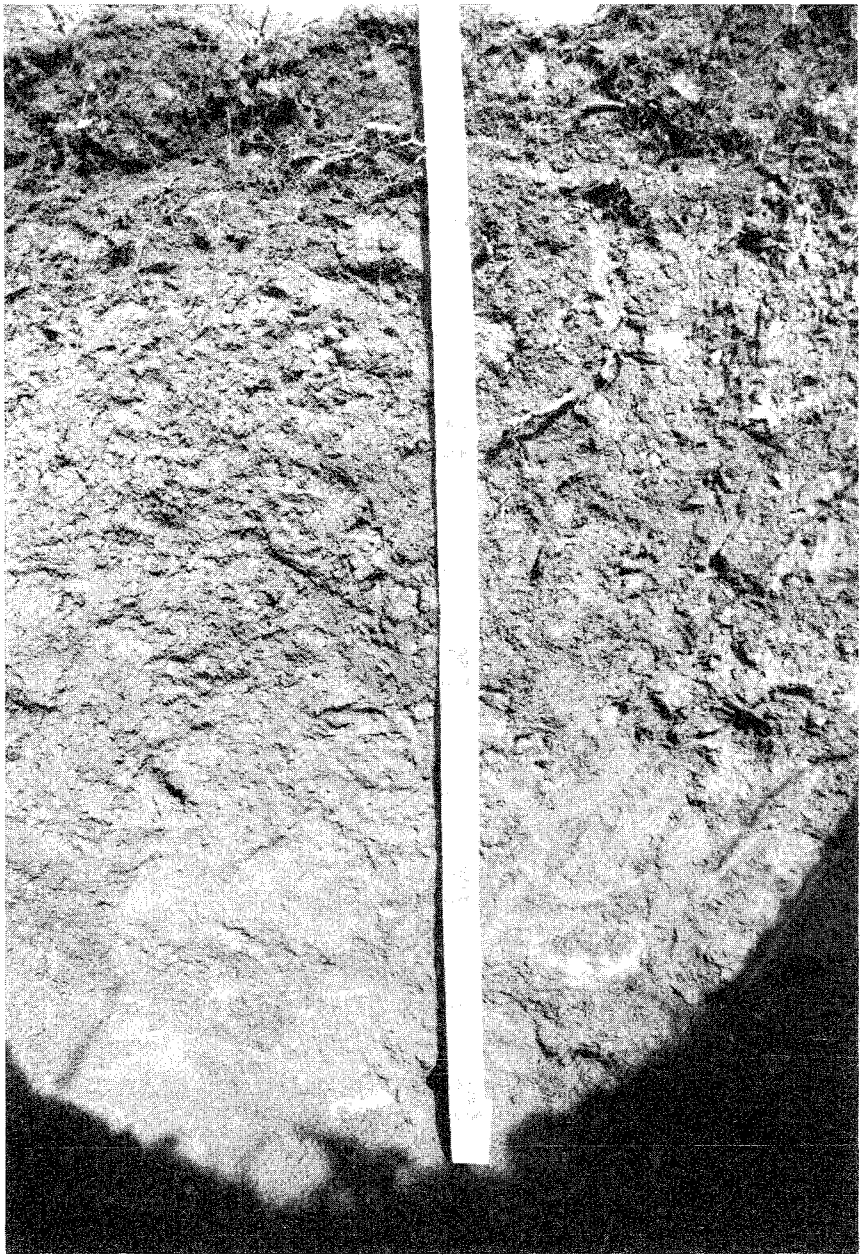
RLWL — The till mantle is less than 20 inches thick in about 35 percent of the unit and more than 40 inches thick in another 15 percent. Peat occurs in about 5 percent of the unit. (Typic Dystrochrepts and Lithic Dystrochrepts)

Table 14. Selected features of soil landscape units within the Highland Moraine, loamy, rolling to hilly (52A) geomorphic area

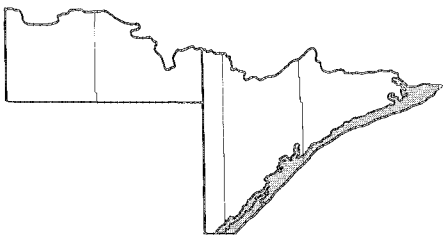
Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWL	73	rolling to hilly	fine sandy loam and loam (2-4)	fine sandy loam and sandy loam (4-20+)	4-8	well and moderately well drained	5.0-5.7	very high	medium	Ahmeek
SSWL	11	rolling to hilly outwash, eskers and ice-contact deposits	very gravelly loamy coarse sand and sandy loam (1-3)	very gravelly coarse sand (3-20+)	<4	excessively drained	5.2-6.2	very high	medium	Toivola Unnamed
NP	9	depressions	peat (1-3)	peat (3+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake Unnamed
SLWL	3	nearly level to hilly outwash plains, eskers and kames	sandy loam (1-2)	sand and gravel (2-20+)	4-8	well drained	5.5-6.1	high	medium	Unnamed

Table 14 (continued). Selected features of soil landscape units within the Highland Moraine, loamy, rolling to hilly (52A) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
RLWL	2	rolling to hilly, shallow to bedrock	gravelly sandy loam (0-3)	bedrock and gravelly sandy loam (3+)	<8	well to excessively drained	5.0-6.6	medium	high	Mesaba Barto Newfound
Lakes	2									



Typical profile of soil landscape unit LLWL, which comprises nearly three-fourths of the Highland Moraine (52A) geomorphic area.



52B Highland Flutes, rocky, strongly sloping

The Highland Flutes enclose approximately 327,400 acres or 10.7 percent of the Two Harbors sheet.

This geomorphic area forms a strongly sloping boundary between the Highland Moraine (52A) and Lake Superior. The flutes, resembling drumlins, are about ½ mile long, ¼ mile apart, and 5 to 20 feet high. The composition is eroded bedrock or linear accumulations of glacial drift. Drift may reach a thickness of 10 to 20 feet, but in many places is less, with outcrops of bedrock being quite common. The water table is normally more than 6 feet deep in well-drained soils and less than 3 feet deep in organic soils. In areas of shallow drift over bedrock the water table may be near the surface during wet periods. Many fast flowing streams cut through the region as they flow toward Lake Superior. Three lakes, each larger than 160 acres and totaling 1,200 acres, are located in the region.

Most of the glacial drift is reddish brown, strongly acid loamy till. Clayey sediments, mostly in glacial lake beds, make up about 30 percent of the region. These are remnants of the high stage of glacial Lake Duluth and several older and smaller glacial lakes. The available water capacity of the soils ranges from very low to high.

Originally the region was covered by red and white pine, balsam fir, and upland spruce. Today it is primarily trembling aspen, balsam fir, and spruce. Five percent or less is in pasture and crops. The main crops are timothy, clover, and oats.

Eight soil landscape units are mapped in this geomorphic area. Table 15 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

LLWL — Approximately 15 percent of the soils in this unit are somewhat poorly and poorly drained. Another 5 percent are very poorly drained. Gravelly, sandy, and organic soils each make up about 5 percent of the unit. Soils in another 10 percent have fragic properties. (Typic Eutroboralfs)

CCWL — Ten to 20 percent of the unit has poorly drained soils. In another 5 percent, bedrock is less than 40 inches below the surface. The unit includes approximately 5 percent loamy soils. (Typic Eutroboralfs)

RLWL — The glacial till is less than 20 inches thick in 35 to 40 percent of the unit, more than 40 inches thick in 5 to 10 percent, and clayey in another 10 percent of the unit. (Typic Dystrochrepts and Lithic Dystrochrepts)

R — Bedrock outcrops in about 30 percent of the unit and glacial drift is more than 20 inches thick in 10 percent. (Lithic Udorthents)

RCWL — Soils in 30 to 40 percent of the unit are gravelly, loamy, and 4 to 20 inches thick over bedrock. Bedrock is more than 40 inches below the clayey soils in 5 to 15 percent of the area. (Typic Eutroboralfs and Lithic Dystrochrepts)

NP — The organic soils are acid in 20 to 30 percent of the unit, and shallow in another 10 to 15 percent. Poorly drained mineral soils make up an additional 5 percent. (Typic Borohemists)

LLPL — Thirty to 35 percent of the unit has very poorly drained soils, 10 to 15 percent has well-drained soils, and about 5 percent has organic soils. (Aeric Glossaquepts)

SSWL — Outliers of glacial till occur in approximately 15 percent of the unit, and shallow loam over sand and gravel make up another 10 to 15 percent. Less than 5 percent is organic soils. (Typic Udorthents)

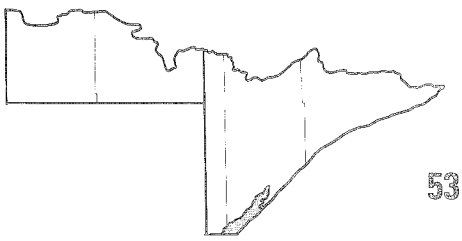
Table 15. Selected features of soil landscape units within the Highland Flutes, rocky, strongly sloping (52B) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWL	28	strongly sloping, drumlin-like upland	loam (2-4)	loam (4-20+)	8-12	well and moderately well drained	5.1-6.0	high	medium	Duluth
CCWL	23	gently sloping to sloping lacustrine	very fine clay (3)	very fine clay (3+)	8-12	moderately well drained	5.2-6.0	low	high	Ontonagon

Table 15 (continued). Selected features of soil landscape units within the Highland Flutes, rocky, strongly sloping (52B) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
RLWL	21	strongly sloping drumlin-like upland	gravelly sandy loam (0-3)	bedrock and gravelly sandy loam (3+)	<8	well drained	5.0-6.0	medium	high	Mesaba Barto Toivola
R	14	strongly sloping to steep, very shallow till and bedrock	gravelly sandy loam and bedrock (0-2)	bedrock and gravelly sandy loam (2+)	<4	well to excessively drained	5.0-6.0	medium	high	Barto Quetico
RCWL	7	clay capped bedrock in lacustrine area	clay and gravelly sandy loam (0-3)	bedrock, clay and gravelly sandy loam (3+)	<8	well drained	5.0-6.0	low	high	Ontonagon (shallow) Barto
NP	3	low lying depressions	peat (1-3)	peat (3+)	>12	very poorly drained	5.5-7.0	low	low	Mooselake Unnamed
LLPL	3	low lying depressions	loam (2-4)	loam (4-20+)	8-12	somewhat poorly to very poorly drained	5.2-5.8	medium	low	Dusler Blackhoof Mahtowa
SSWL	1	sloping to strongly sloping outwash and ice-contact deposits	gravelly loamy coarse sand (1-3)	gravelly coarse sand (3-20+)	<4	excessively drained	5.2-6.2	very high	medium	Toivola Unnamed
Lakes	<1									

Only a few inches of loamy soil overlie bedrock in this example of soil landscape unit R in the Highland Flutes (52B).



53 Nemadji-Duluth Lacustrine Plain, clayey

The Nemadji-Duluth Lacustrine Plain, encompasses approximately 69,700 acres or 2.3 percent of the Two Harbors sheet.

This clayey plain is partly dissected by streams and is about 1,000 feet above sea level or 400 feet above the present level of Lake Superior. A few prominent "islands" of bedrock partially covered by shallow clayey, loamy, and gravelly sediments are located in the region. The water table is normally 6 feet deep or more. There are no lakes.

The clayey lacustrine sediments are reddish brown and calcareous. The available water capacity is high.

The original vegetation was dominantly white pine, hard maple, eastern hemlock, and white spruce. Today, 90 to 95 percent of the area is wooded. The main species are trembling aspen, white spruce, and maple. Five to 10 percent is pasture and cropland. Timothy and oats are the main crops.

Three soil landscape units are mapped in this geomorphic area. Table 16 lists the principal characteristics of each unit. The following paragraphs further describe the units and list inclusions which are different from the majority of soils in the unit. The term in parentheses is the approximate classification of the soil landscape unit at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

CCWL — Inclusions consist of 5 to 10 percent poorly drained soils, 5 to 10 percent soils with less than 40 inches to bedrock, about 5 percent gravelly and sandy soils, and less than 5 percent organic soils. (Typic Eutroboralfs)

RLWL — In 30 to 40 percent of this unit, bedrock occurs within 20 inches of the surface and in 5 to 10 percent of the unit it occurs below 40 inches. In another 5 to 10 percent the material overlying bedrock is clayey. (Typic Distrochrepts and Lithic Distrochrepts)

RCWL — In most of the clayey soils bedrock is within 40 inches of the surface. Twenty to 30 percent of the unit consists of gravelly and loamy soils less than 20 inches thick over bedrock. (Typic Eutroboralfs and Lithic Dystrochrepts)

Table 16. Selected features of soil landscape units within the Nemadji-Duluth Lacustrine Plain, clayey (53) geomorphic area

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
CCWL	94	gently sloping to sloping lake plain	very fine clay (3)	very fine clay (3+)	8-12	moderately well drained	5.2-6.0	low	high	Ontonagon
RLWL	5	strongly sloping drumlin-like upland	gravelly sandy loam (0-3)	bedrock and gravelly sandy loam (3+)	<8	well drained	5.0-6.0	medium	high	Mesaba Barto Toivola
RCWL	1	clayey and loamy capped bedrock outcrops	clay and gravelly sandy loam (0-3)	bedrock, clay and gravelly sandy loam	<8	well to excessively drained	5.2-6.0	low	high	Ontonagon (shallow) Barto

Development of Landforms

Two Harbors Sheet

Most of the landforms in the area of the Two Harbors sheet resulted either directly or indirectly from glacial action more than 10,000 years ago. Two geomorphic areas, however, the Mesabi Range (16) and the Tower-Ely Glacial Drift and Bedrock Complex (19) consist largely of Precambrian crystalline rocks. The bedrock is overlain by thin patches of glacial drift, probably from the Rainy lobe. The most striking glacial features in these two areas are the striations on the exposed bedrock. These scratches resulted as rocks, frozen to the base of the glaciers, were scraped across the surface of the bedrock. Geomorphic area 19 also occurs extensively in the eastern portion of the International Falls sheet.

The geomorphic features formed by glacial processes are largely the result of advances by two major ice lobes, the Rainy lobe and the Superior lobe. The Rainy lobe advanced from the northeast sometime between 16,000 and 35,000 years ago and formed the Toimi Drumlin Area (15). During the same time the Superior lobe occupied the Lake Superior basin. Both lobes were moving toward the southwest and were separated subglacially by the coastal hills. The ice surface, however, was most likely continuous between the two lobes.

During the retreat of the Rainy lobe the Allen Moraine (27), the Big Rice Moraine (18B), and the Vermilion Moraine (18C) were formed. A small portion of the Vermilion also is mapped on the International Falls sheet. Meltwater from the wasting ice produced the Big Rice Outwash Plain (17) and the Sawbill Outwash Plain (17A). The retreat of the Rainy and Superior lobes ended the St. Croix phase of Wisconsin glaciation. The Rainy lobe withdrew northward at least to the Vermilion Moraine (18C), and the Superior lobe probably retreated into the Lake Superior basin.

Stagnant ice was abundant in areas formerly occupied by the Rainy lobe, especially in moraine and outwash deposits. In the northeast portion of the Vermilion Moraine (18C), lowland areas were filled by large masses of ice, many of which were buried as debris was washed in by meltwater. Subsequent melting of the buried ice caused collapse and slumping of the overlying deposits. As a result the topography in this area is extremely irregular, with particle sizes ranging from sand to boulders. Similar conditions, though to a lesser degree, probably existed in other areas of soil landscape unit SSWL within the Vermilion Moraine (18C) and the Sawbill Outwash Plain (17A).

Landforms along the North Shore of Lake Superior where topography is controlled largely by bedrock.

Many eskers were formed during the wasting of the Superior and Rainy lobes. These eskers were probably formed by streams flowing beneath the glaciers in ice-walled gorges or ice tunnels. As the volumes of flowing water decreased, the streams began to lose their capacity to transport sediment. As a result, sand and gravel were deposited along the subglacial channels. Most of the eskers are located in the Tower-Ely Glacial Drift and Bedrock Complex (19) and the Vermilion Moraine (18C).

During the Automba phase, the Superior lobe readvanced west-southwest and west out of the Superior basin. Along the lobe's flank the ice moved at right angles to the present shore of Lake Superior, forming the Highland Flutes (52B) and the Highland Moraine (52A). Then the Rainy lobe was located at the Vermilion Moraine (18C). Meltwaters from the Rainy and the Superior lobes formed the Brimson Outwash Plain (23).

The Superior lobe readvanced again during the Split Rock phase, but did not have any significant effect on landform development in the Two Harbors sheet.

The Superior lobe readvanced again during the Nickerson phase. Contemporaneous with it was the Alborn phase of the St. Louis sublobe, an offshoot of the Des Moines lobe. As these two ice sheets retreated, meltwaters formed proglacial Lake Nemadji. The lake drained to the southwest into the Moose River at an elevation of 1,060 feet. As the Superior lobe withdrew further into the Lake Superior basin, a lower outlet was uncovered in Wisconsin leading into the Brule River. The water level lowered to 1,010 feet where it stabilized as glacial Lake Duluth. Clayey sediments from these two lakes comprise the parent materials of nearly all the soils of the Nemadji-Duluth Lacustrine Plain (53).

Several stream valleys in Cook County have been occupied at various times by glacial lakes which received meltwater and debris from the ice. Beds of red clay, locally calcareous, and in some places underlain by layers of brown non-calcareous clay and silt, are evidence of their former existence. Three such valleys, the Poplar River at an elevation of 1,309 feet, the Onion River at 1,250 feet, and the Temperance River at 1,240 feet, are located in southwestern Cook County north of the coastal hills. These lake beds are too narrow to delineate on the map. Another former lake, located near Mineral Center (T-63N, R-5E) at 1,350 feet, has at least 7 feet of red clay. Shallower clays are found along Stump and Swamp rivers, both at elevation 1,385 feet. Lacustrine deposits along Pigeon River are about 20 feet thick at an elevation of 980 feet. All of these lake beds, except the Pigeon River, have an upper limit above the known or postulated level of glacial Lake Duluth in this area. They must therefore be considered older features.

After glaciation, landform development continued in several ways. In scattered areas a thin mantle of wind-blown material was deposited on the surface of the glacial drift. In low-lying areas peat began to accumulate, a process favored by the cool, wet environment.

International Falls Sheet

Nearly half of the International Falls sheet is mapped as the Tower-Ely Glacial Drift and Bedrock Complex (19). This geomorphic area was probably last glaciated by the Rainy lobe, but the landforms consist largely of Precambrian crystalline rocks overlain by only thin patches of glacial drift. Landscape features more closely related to glaciation are prevalent in the remainder of the sheet area.

The Vermilion Moraine (18C), deposited by the Rainy lobe, is the only moraine feature mapped on the International Falls sheet. The largest part of this moraine is mapped on the Two Harbors sheet.

The western portion of the map area was glaciated by part of the St. Louis sublobe. An offshoot of the Des Moines lobe, this sublobe advanced southeastward along the Red Lakes lowland. The till that was deposited is generally calcareous, loamy, and quite thin, probably less than 25 feet. In the area of the International Falls sheet, the till was subsequently covered by lake sediments from glacial Lake Agassiz.

Lake Agassiz formed during late Wisconsin glaciation when meltwaters became ponded between the retreating ice and higher land to the south. During the lake's complex history, its size and location varied considerably, depending on the position of the ice margin. The lacustrine plain of Lake Agassiz is very large, with only a small portion occurring within the map area.

During the Lockhart phase of Lake Agassiz, waters spread into the basin of the Rainy River. Clayey sediments were deposited by the lake throughout the Big Fork Area (1B) and Agassiz Peatlands (1F) geomorphic areas. As the level of the lake lowered, some of these sediments were sorted by wave action to form sandy areas.

After the lake receded, large areas of peat formed over much of the lake bed, especially in the Agassiz Peatlands (1F). Peat accumulation was favored by the cool, wet environment. The largest acreage of these peatlands occurs west of the map area.

Climate

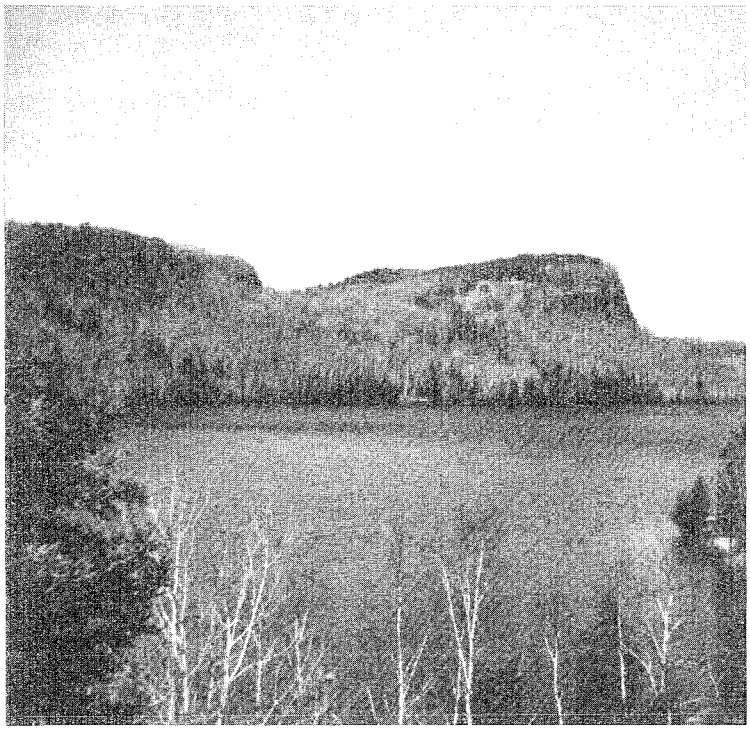
The climate of northeastern Minnesota, particularly along the North Shore, is greatly influenced by Lake Superior. Both temperature and precipitation are affected.

The modifying effect of the lake results in cooler summer and warmer winter temperatures. This effect diminishes when ice covers the western part of the lake, generally during February and March. Then temperatures of the area are more like the rest of the state, which has a continental climatic regime.

Precipitation patterns during the spring and fall blend in with the rest of the state; however, summer and winter precipitation is influenced by Lake Superior. From mid-May through August, warm air passing over the cold surface of the lake is stabilized and cooled, occasionally to the point of condensation. Smaller precipitation amounts are recorded northeast along the North Shore, because the air trajectory over the lake likewise increases to the northeast.

In the winter, from mid-November to February before the western part of the lake freezes, snowfall increases locally near the lake. Southerly and easterly winds crossing the open lake absorb large amounts of moisture. As the air moves up and over the snow-covered shore and highland, it is cooled and triggers condensation and precipitation in the form of snow. This results in a belt of heavy snowfall occurring 5 to 7 miles inland from the lake shore.

General climatic characteristics of the International Falls and Two Harbors sheet areas are illustrated in figures 1 through 9.



The cold waters of Lake Superior have a significant effect on the climate of northeastern Minnesota.

The dashed boundary line --- delineates a portion of the Hibbing sheet (Soil Atlas) map that has been included in this International Falls-Two Harbors climate map series.

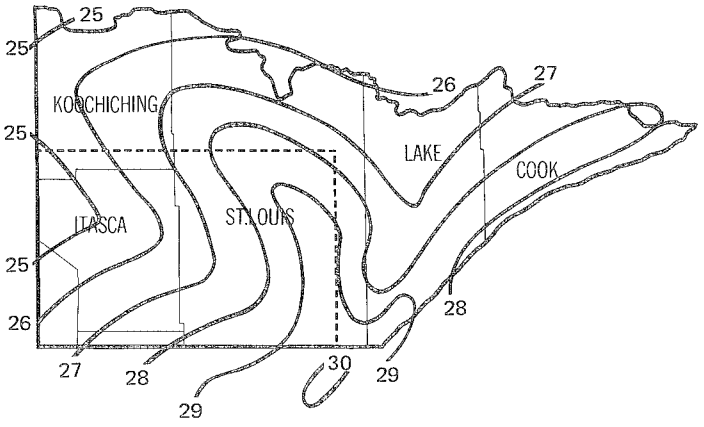


Figure 1. Annual normal precipitation in inches, 1940-71. (Adapted from Minnesota Technical Bulletin 314, 1978)

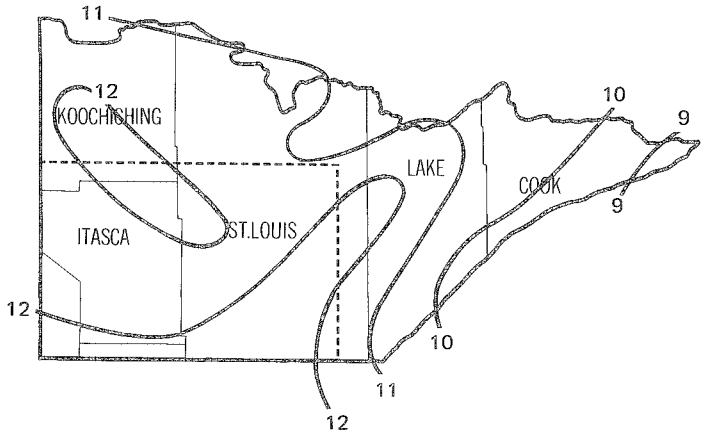


Figure 2. Summer (June, July, August) normal precipitation in inches, 1941-70. (Adapted from Minnesota Technical Bulletin 314, 1978)

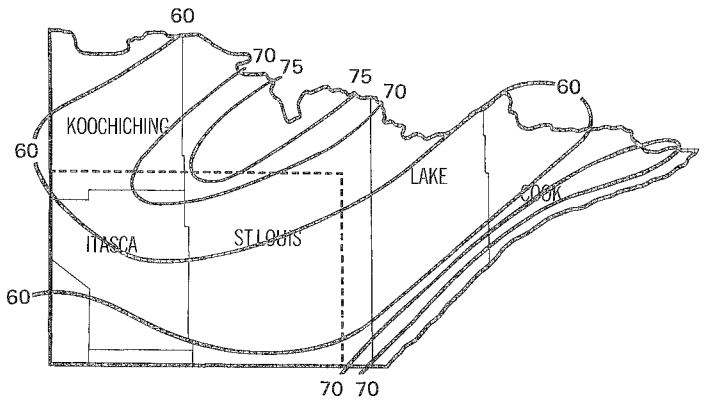


Figure 3. Seasonal snowfall in inches, based on median values, 1950-75. (Prepared by E. L. Kuehnast, state climatologist)

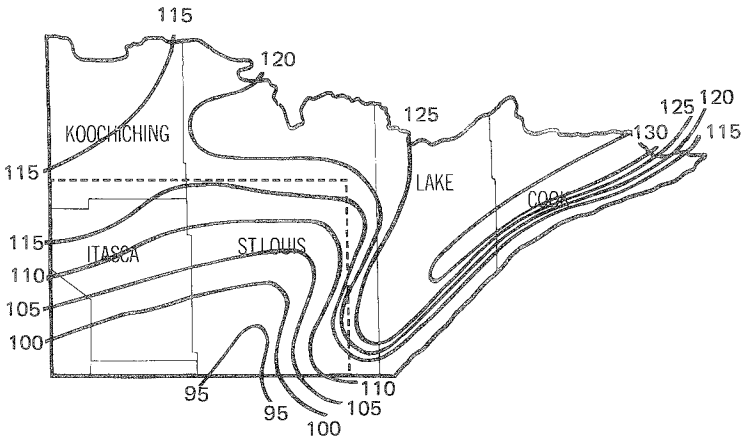


Figure 4. Average number of days when snow cover is greater than 6 inches, 1960-79. (Prepared by E. L. Kuehnast, state climatologist)

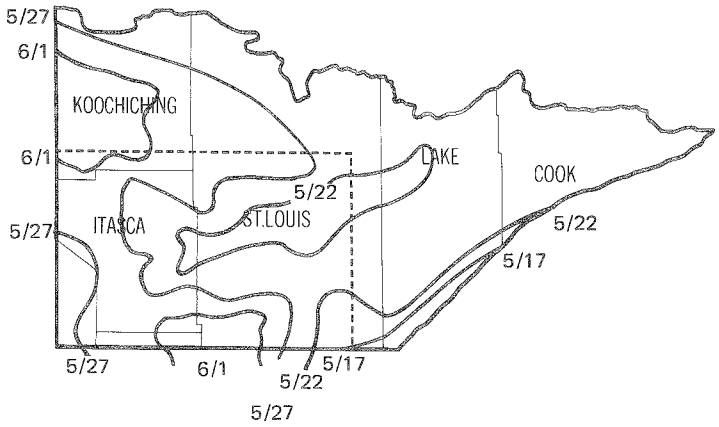


Figure 7. Average date of last occurrence of 32°F or lower in spring. (Adapted from Minnesota Technical Bulletin 243, 1963)

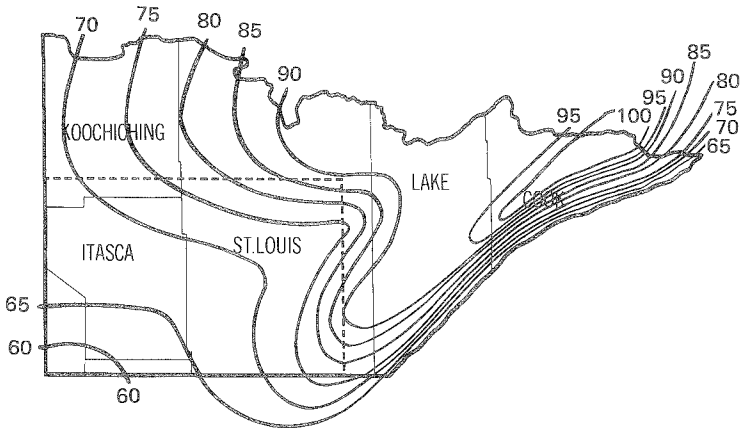


Figure 5. Average number of days when snow cover is greater than 12 inches, 1960-79. (Prepared by E. L. Kuehnast, state climatologist)

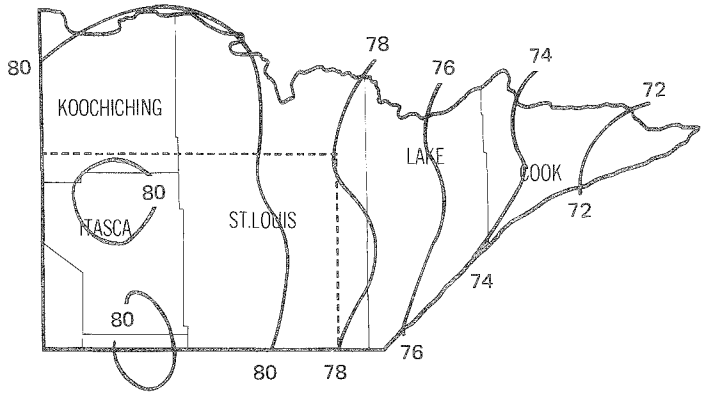


Figure 8. Average daily maximum temperature during July, 1951-70. (Adapted from Climatography of the United States. No. 60-21. U.S. Department of Commerce, 1972)

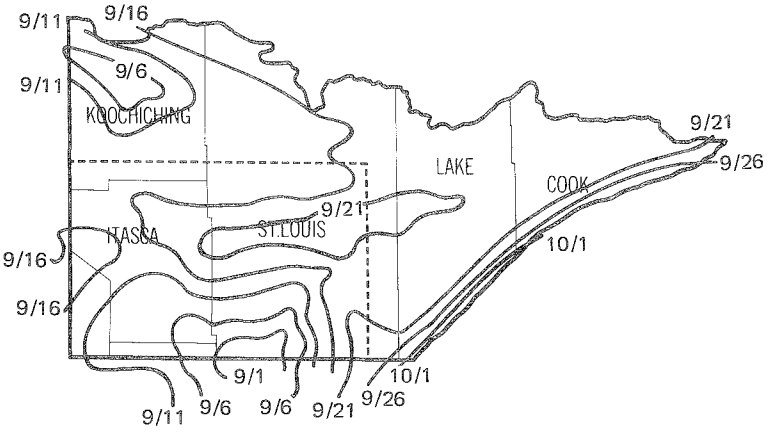


Figure 6. Average date of first occurrence of 32°F or lower in the fall. (Adapted from Minnesota Technical Bulletin 243, 1963)

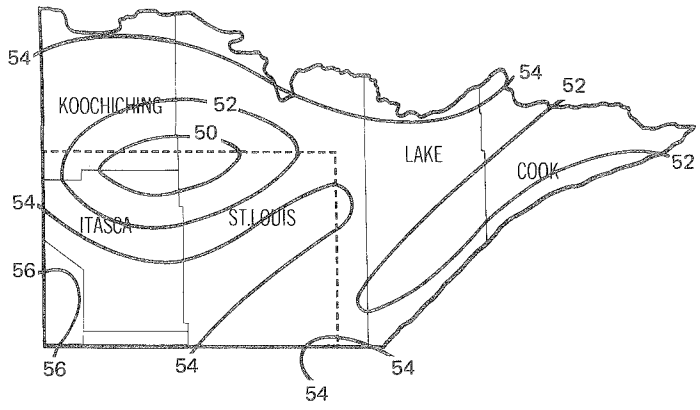


Figure 9. Average daily minimum temperature during July, 1951-70. (Adapted from Climatography of the United States. No. 60-21. U.S. Department of Commerce, 1972)

Forestry

Forestry is the most important land use in the area of the International Falls and Two Harbors sheets. During the early logging period, pine and spruce were the principal species of the region. Today, aspen, birch, red pine, and jack pine occur extensively and are important to the aesthetic beauty and forest products industry of the area.

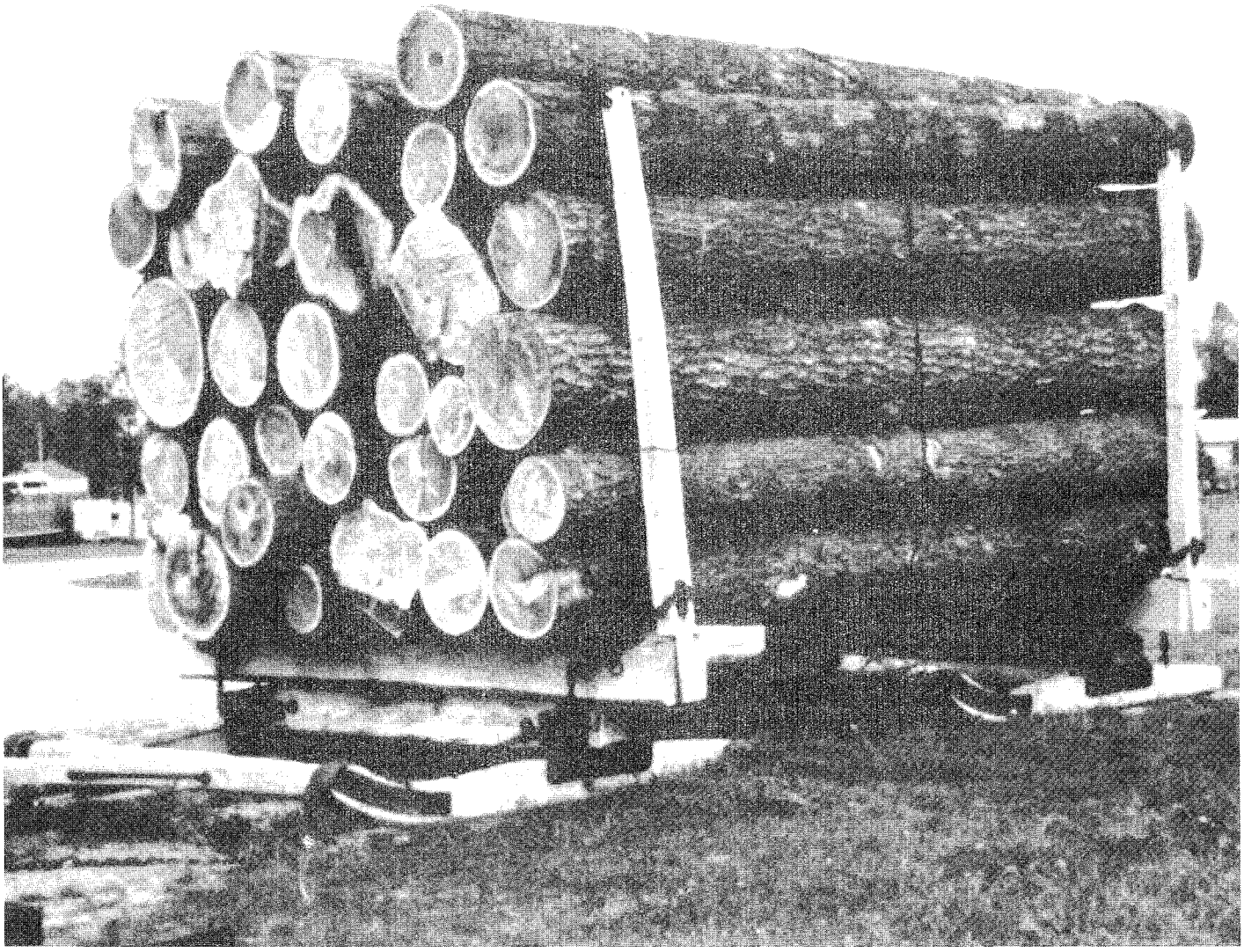
Table 17 indicates selected forestry interpretations for the soil landscape units. The interpretations include seedling mortality, species recommendations, and productivity for pulpwood and sawtimber. These are based on the physical and chemical characteristics of the soils, prevailing water table positions, and general climatic conditions. Problems of disease and insect control are also reflected in the interpretations.

Table 17. Selected forestry interpretations by soil landscape unit

Soil landscape units	Texture	Water table position	Seedling mortality	Root restrictions	Forest productivity		Recommended species
					Pulpwood	Sawtimber	
LLWL	loamy (numerous stones and cobbles)	low	slight to moderate	slight	good	fair to good	red pine jack pine white spruce aspen white birch black spruce
LLPL	loamy	high to medium	moderate to severe	moderate to severe	good	fair to good	black spruce white spruce black ash white cedar aspen
CCWL	clayey	medium to low	moderate to severe	moderate	good	good to fair	white spruce white cedar black ash white birch aspen
LCPL CCPL CCPD	silty clay over clay or loam	high to medium	moderate to severe	moderate to severe	good	fair	black spruce white spruce white pine black ash
SLWL LSWL	loamy very fine sand, fine sand, or sandy loam over loam or sand and gravel	low	slight	slight	good	good	red pine aspen jack pine white birch white spruce
SSPL CSPL LSPL	loamy very fine sand to fine sand over fine sand, loam, or clay	high to medium	moderate to severe	moderate to severe	fair	poor	black spruce white spruce aspen black ash white cedar

Table 17. (continued). Selected forestry interpretations by soil landscape unit

Soil landscape units	Texture	Water table position	Seedling mortality	Root restrictions	Forest productivity		Recommended species
					Pulpwood	Sawtimber	
SSWL RLWL RSWL RCWL R	loamy, sandy, and clayey 2-10' thick over bedrock or sand and gravel	low	slight to moderate	slight to moderate	good	fair	jack pine red pine aspen white spruce black spruce
NP AP BP P A MD	peat, variable, or bedrock	high to low	moderate to severe	severe	fair	poor	black spruce white cedar black ash tamarack



The logging industry, once the cause of an economic boom, still contributes to the economy of northeastern Minnesota.

Recreation

Numerous lakes occur within the area of the International Falls and Two Harbors sheets. During the summer vacation season fishing, swimming, boating, and canoeing are popular recreational activities. Excellent conditions for canoeing are found in Voyageur's National Park and the Boundary Waters Canoe Area. Both areas contain a complex pattern of lakes, islands, bays, peninsulas, and winding streams.

Hunting is a popular sport in both map areas during the autumn months. Game species include deer, bear, ducks, geese, and grouse. Snowmobiling, skiing, and ice fishing are the most common winter sports. Table 18 lists the principal recreational activities within each geomorphic area in the two sheets.

Table 19 outlines the limitations for various recreational land uses in the soil landscape units of the International Falls and Two Harbors sheets. In selecting recreational areas the total landscape must be considered. Several soil landscape units may occur in a given area and these should be evaluated collectively. The association of land and water is another important consideration.

Table 18. Recreational activities by geomorphic area

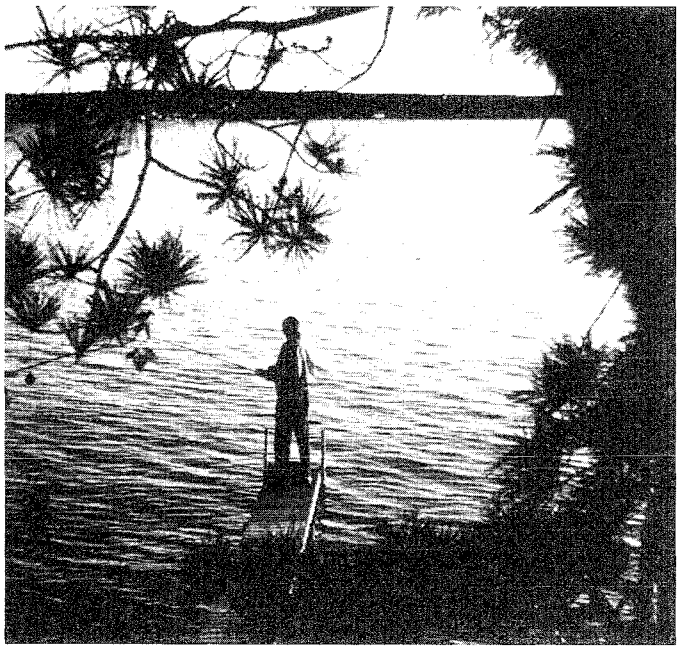
Geomorphic area		Principal game	Water oriented	Resorts, picnic and campgrounds	Skiing	Snowmobiling	Additional information
1B	Agassiz Lacustrine Plain Big Fork Area	Deer, grouse moose, bear	Canoeing on Big Fork and Little Fork Rivers and larger tributaries	Campsites along canoe routes		limited	High public ownership
1F	Agassiz Peatlands	Deer, grouse moose, bear	limited	none		limited	
15	Toimi Drumlin Area, loamy	deer, grouse, moose		camp and picnic grounds		limited	wilderness—somewhat isolated
16	Mesabi Range				fair	limited	
17	Big Rice Outwash Plain	deer, grouse				limited	
17A	Sawbill Outwash Plain	deer, grouse	fishing			limited	
18B	Big Rice Moraine	deer, grouse				limited	
18C	Vermilion Moraine	deer, grouse	some boating and fishing			limited	
19	Tower-Ely Glacial Drift and Bedrock Complex	wolves, deer, bear	boating, fishing, canoeing	camp and picnic grounds; lodges and cabins especially in Ely area, on Rainy and Crane Lakes and lakes in vicinity of Orr	good	extensive	Boundary Waters Canoe Area; Echo and Gunflint Trails; Continental Divide; Voyageur National Park; wilderness—virtually isolated
23	Brimson Outwash Plain, sandy	deer, grouse				extensive	
27	Allen Moraine	deer, grouse				extensive	
52A	Highland Moraine, loamy, rolling to hilly	deer, grouse, bear	boating and fishing	resorts, cabins, camp and picnic grounds especially along Lake Superior	good	extensive	
52B	Highland Flutes, rocky, strongly sloping	deer, grouse bear		resorts, cabins, camp and picnic grounds along Lake Superior	good	extensive	scenic drive along North Shore of Lake Superior
53	Nemadji-Duluth Lacustrine Plain, clayey			camp and picnic grounds; resorts along Lake Superior			

Table 19. Degree and kinds of limitations for specific recreational uses by soil landscape unit

Soil landscape unit	Playground, athletic field and intensive play areas	Picnic areas, parks and extensive play areas	Bridle paths, nature and hiking trails	Golf course fairways	Cottages, service, and utility buildings	Tents and trailer sites
SSWL	Moderate to severe—difficult to maintain vegetation Moderate—sandy surface soil Moderate—2-6% slope Severe—over 6% slope	Moderate—difficult to maintain vegetation, sandy surface soil Moderate—6-12% slope Severe—over 12% slope	Moderate—sandy surface soil Moderate—12-18% slope Severe—over 18% slope	Severe—difficult to maintain vegetation, low natural fertility Moderate—sandy surface soil Moderate—6-12% slope Severe—over 12% slope	Slight—difficult to maintain vegetation on sandy surface soil Slight—0-6% slope Moderate—6-12% slope Severe—over 12% slope	Moderate—sandy surface soil Moderate—6-12% slope Severe—over 12% slope
SSPL	Moderate—high water table	Moderate—high water table	Moderate—high water table	Moderate—high water table, low natural fertility	Severe—high water table	Severe—high water table
SLWL	Slight—0-2% slope Moderate—2-6% slope Severe—over 6% slope	Slight—2-6% slope Moderate—6-12% slope Severe—over 12% slope	Slight—2-12% slope Moderate—12-18% slope Severe—over 18% slope	Slight—2-6% slope Moderate—6-12% slope Severe—over 12% slope	Slight—2-6% slope Moderate—6-12% slope Severe—over 12% slope	Slight—2-6% slope Moderate—6-12% slope Severe—over 12% slope
LLWL	Slight—0-2% slope Moderate—2-6% slope Severe—over 6% slope, surface stones and cobbles in places	Slight—0-6% slope Moderate—6-12% slope Severe—over 12% slope	Slight—0-12% slope Moderate—12-18% slope Severe—over 18% slope	Slight—0-6% slope Moderate—6-12% slope Severe—over 12% slope	Slight—0-6% slope Moderate—6-12% slope, frost action Severe—over 12% slope	Slight—0-6% slope Moderate—6-12% slope Severe—over 12% slope
LLPL	Severe—high water table, frequently ponded Moderate—surface soil sticky and soft in places	Severe—high water table, frequently ponded Moderate—surface soil sticky and soft in places	Severe—high water table, frequently ponded Moderate—surface soil sticky and soft in places	Severe—high water table, frequently ponded Moderate—surface soil sticky and soft in places	Severe—high water table, frequently ponded	Severe—high water table frequently ponded
LSWL	Moderate—vegetation difficult to maintain in some places Moderate—2-6% slope Severe—over 6% slope	Moderate—vegetation difficult to maintain in some places Moderate—6-12% slope Severe—over 12% slope	Slight—0-12% slope Moderate—12-18% slope	Moderate—vegetation difficult to maintain in some places Moderate—6-12% slope Severe—over 12% slope	Slight—0-6% slope Moderate—6-12% slope Severe—over 12% slope	Slight—0-6% slope Moderate—6-12% slope Severe—over 12% slope
LSPL	Moderate—high water table	Moderate—high water table	Moderate—high water table	Moderate—high water table	Severe—high water table	Severe—high water table
CCWL	Severe—surface soil very sticky and soft when wet, clayey surface soil, very low permeability Severe—over 6% slope	Severe—surface soil very sticky and soft when wet, clayey surface soil, very low permeability Severe—over 12% slope	Severe—surface soil very sticky and soft when wet, clayey surface soil, very low permeability Severe—over 12% slope	Severe—surface soil very sticky and soft when wet, clayey surface soil, very low permeability Severe—over 12% slope	Severe—shrink-swell, low strength, very low permeability Severe—over 12% slope	Severe—surface soil very sticky and soft when wet, clayey surface soil Severe—over 12% slope
CCPL CCPD LCPL	Severe—high water table, frequently ponded; surface soil very sticky and soft when wet	Severe—high water table, frequently ponded; surface soil very sticky and soft when wet	Severe—high water table, frequently ponded; surface soil very sticky and soft when wet	Severe—high water table, frequently ponded; surface soil very sticky and soft when wet	Severe—high water table, frequently ponded	Severe—high water table, frequently ponded
CSPL	Moderate—high water table	Moderate—high water table	Moderate—high water table	Moderate—high water table	Severe—high water table	Severe—high water table

Table 19 (continued). Degree and kinds of limitations for specific recreational uses by soil landscape unit

Soil landscape unit	Playground, athletic field and intensive play areas	Picnic areas, parks and extensive play areas	Bridle paths, nature and hiking trails	Golf course fairways	Cottages, service, and utility buildings	Tents and trailer sites
RLWL	Severe—shallow to bedrock, rock outcrops occur Severe—over 6% slope	Moderate—6-12% slope Severe—over 12% slope	Moderate—12-18% slope Severe—over 18% slope	Moderate—6-12% slope, productivity medium to low Severe—over 12% slope	Moderate—shallow to bedrock, rock outcrops occur Moderate—6-12% slope Severe—over 12% slope	Moderate—6-12% slope Severe—over 12% slope
RSWL	Severe—over 6% slope, shallow to bedrock, rock outcrops occur, vegetation difficult to maintain in places	Moderate—6-12% slope, vegetation difficult to maintain in places Severe—over 12% slope	Moderate—sandy surface soil Moderate—12-18% slope Severe—over 18% slope	Moderate—vegetation difficult to maintain in places, productivity medium to low Moderate—6-12% slope Severe—over 12% slope	Moderate—shallow to bedrock, rock outcrops occur, vegetation difficult to maintain Moderate—6-12% slope Severe—over 12% slope	Moderate—6-12% slope Severe—over 12% slope
RCWL	Severe—surface soil very sticky and soft when wet, clayey surface soil, shallow to bedrock, rock outcrops occur Severe—over 6% slope	Severe—surface soil very sticky and soft when wet, clayey surface soil, very low permeability Severe—over 12% slope	Severe—surface soil very sticky and soft when wet, clayey surface soil, very low permeability Severe—over 18% slope	Severe—surface soil very sticky and soft when wet, clayey surface soil, medium to low productivity Severe—over 12% slope	Severe—shrink-swell, low strength, shallow to bedrock, rock outcrops occur, very low permeability Severe—over 12% slope	Severe—surface soil very sticky and soft when wet, clayey surface soil Severe—over 12% slope
R	Severe—bedrock exposed, vegetation difficult to maintain in places Severe—over 6% slope	Moderate—bedrock exposed, vegetation difficult to maintain in places Severe—over 12% slope	Moderate—12-18% slope Severe—over 18% slope	Severe—bedrock exposed Severe—over 12% slope	Severe—bedrock limits sewage disposal Severe—over 12% slope	Severe—bedrock exposed Severe—over 12% slope
NP, AP, P, BP	Severe—high water table, seasonally ponded, soft organic surface soil	Severe—high water table, seasonally ponded, soft organic surface soil	Severe—high water table, seasonally ponded, soft organic surface soil	Severe—high water table, seasonally ponded, soft organic surface soil	Severe—high water table, seasonally ponded, soft organic surface soil	Severe—high water table, seasonally ponded, soft organic surface soil
MD	unfavorable for recreational use					



Fishing and scenic beauty attract many tourists to the lakes of northeastern Minnesota.

Information for the Engineer

Because of the general nature of soil landscape units, which include several major and minor soil series, it is impossible to give specific engineering data such as engineering classification, particle size, liquid limit, plasticity index, percolation rates, shrink-swell potential, and corrosivity. These must be obtained from on-site investigations. Table 20 gives an approximate range in the AASHTO and unified classification of materials in the respective soil landscape units.

Engineers may find this map useful for locating sources of sand and gravel. Large peat areas which may cause difficulties in road location can also be identified. Landscape units with clay generally have high shrink-swell potential.

Prime sources of gravel occur in the Big Rice Outwash Plain (17), Sawbill Outwash Plain (17A), and the Brimson Outwash Plain (23). Within the Big Rice Moraine (18B), Vermilion Moraine (18C), Allen Moraine (27), and Highland Moraine (52A), sand and gravel occur in soil landscape unit SSWL.

Bedrock is generally shallow in the Tower-Ely Glacial Drift and Bedrock Complex (19), but is also shallow in other geomorphic areas where the RLWL, R, RSWL, and RCWL soil landscape units are mapped.

Table 20. Approximate engineering classification of materials in soil landscape units

Soil landscape unit	AASHTO[1]		Unified[2]	
	Surface	5 feet+	Surface	5 feet+
SSWL	A-2, A-2-4	A-1, A-2, A-3, A-2-4	SP, SP-SM, SM	SP, SP-SM, SM, GP
SSPL	A-2, A-2-4	A-1, A-2, A-3, A-2-4	SP, SP-SM, SM	SP, SP-SM, SM, GP
SLWL	A-2, A-4	A-1, A-2, A-3, A-2-4	SM, SM-SC	GW, GP, SP
LSWL	A-2, A-2-4	A-4, A-6	SP, SP-SM, SM	SM, SC, SM-SC, ML
LSPL	A-2, A-2-4	A-4, A-6	SP, SP-SM, SM	SM, SC, SM-SC, ML
LLWL	A-2-4, A-4, A-6	A-2-4, A-4, A-6	SM, ML, CL	SM, ML, ML-CL, CL
LLPL	A-2-4, A-4, A-6	A-2-4, A-4, A-6	SM, ML, CL	SM, ML, ML-CL, CL
LCPL	A-7	A-2-4, A-4, A-6	CL, CH	SM, ML, ML-CL, CL
CSPL	A-2, A-2-4	A-6, A-7	SP, SP-SM, SM	CL, ML-CL, MH-CH
CCWL	A-7	A-7	CL, CH	CL, CH
CCPL	A-7	A-7	CL, CH	CL, CH
CCPD	A-7	A-7	CL, CH	CL, CH
RSWL	A-2-4	A-2-4, bedrock	SM, SM-SC	SM, SM-SC, bedrock
RLWL	A-2-4, A-6	A-2-4, A-6, bedrock	SM, CL	SM, CL, bedrock
RCWL	A-7	A-7, bedrock	CL, CH	CL, CH, bedrock
R	A-2-4, A-6, bedrock	bedrock	SM, CL, bedrock	bedrock
BP	A-8	A-8	Pt	Pt
NP	A-9	A-8	Pt	Pt
AP	A-8	A-8	Pt	Pt
P	A-8	A-8	Pt	Pt
A	variable	variable	variable	variable
MD	—	—	—	—

[1]American Association of State Highway (Transportation) Officials. Standard Specification for Highway Materials and Methods of Sampling and Testing. 1961.
[2]Waterways Experiment Station, U.S. Army Corps of Engineers. The Unified Soil Classification System. Tech. Memo 3-357, Vol. 2, 1953.

Water Resources[1]

The city of International Falls and nearby paper mills rely on the Rainy River for their water supplies. Municipal water for Ely comes from Burntside Lake. Communities along the North Shore take water from Lake Superior. Canoeists in the Boundary Waters Canoe Area generally use surface water for drinking. Virtually all other domestic water is supplied from ground water, although development has been very limited because of sparse population. Most well water is hard and may be high in iron and manganese.

Ground Water

The most readily available ground water occurs in the outwash plains of the Two Harbors sheet (geomorphic areas 17, 17A, and 23). Recharge is rapid through the sand and gravel, but in areas where the outwash deposits are thin, storage capacity is limited. Wells in deep outwash may yield up to 1,000 gallons per minute.

Glacial moraines with ice contact features and buried lenses of sand and gravel are also good sources of ground water. Moraine areas occur in geomorphic areas 18B, 18C, 27, and 52A, and are all located within the Two Harbors sheet area except for a small portion of 18C. Wells in deep sand and gravel deposits may yield as high as 1,000 gallons per minute. Much lower yields would be expected from finer-textured materials.

Ground water is generally less available in the till areas of geomorphic areas 15 and 16. Availability of water and recharge rates are quite variable, depending on the presence of aquifers and the thickness of the till over bedrock.

Availability of ground water is also rather low in the lacustrine plain of Lake Agassiz (geomorphic areas 1B and 1F). The plain consists mainly of lacustrine clays and peat underlain by glacial till with bedrock at 50 to 150 feet below the surface. Aquifers located in the glacial till are the best sources of ground water, but the extent of these is quite small. Bedrock contains smaller amounts of available water and has much lower recharge rates than does the glacial till. Peatlands serve as reservoirs of ground water; however, movement into the till is slow. Most wells in the lake plain are from 20 to 150 feet deep.

Information on ground water in geomorphic area 53 is very limited since most communities there rely on Lake Superior for their water supplies. Most of the area consists of lacustrine clay underlain by till or bedrock. Recharge is slow in the till and very slow in the clay and bedrock.

Bedrock is the only source of ground water in much of geomorphic areas 19 and 52B. Wells in these areas commonly yield less then five gallons per minute. Development of ground water is mainly in the vicinity of Pelican Lake, where the depth of glacial drift may exceed 50 feet.

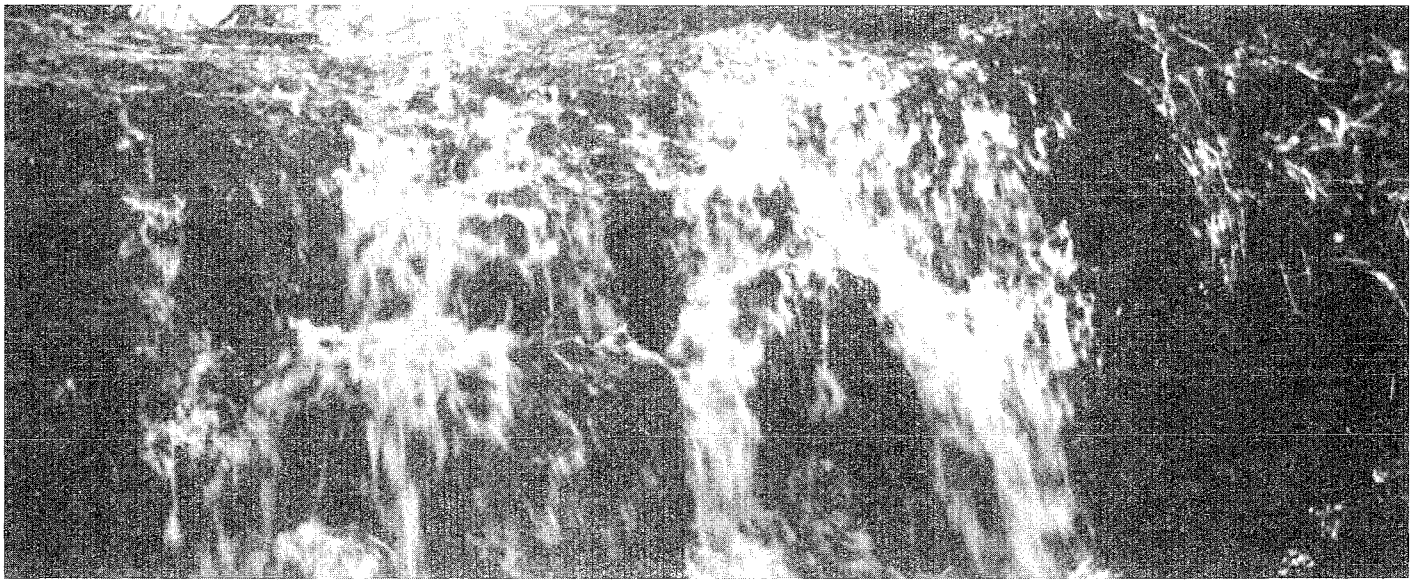
Surface Water

The lakes of the International Falls and Two Harbors sheet areas are important to the ecology and recreational potential of the region. Nearly 400 lakes larger than 160 acres are located here, with an additional 28 along the border with Canada. About 90 percent of the lakes are within geomorphic area 19. The quality of these wilderness waters is generally excellent.

Numerous streams also contribute to the water resources of the region. Annual maximum flows usually occur in April or early May following snowmelt. High flows are sustained by the natural regulating influence of lakes and peatlands. Flows are most reliable on main streams, and least reliable on minor tributaries. Annual low flows occur in winter when water is stored as snow and ice, and during dry periods in late summer or early fall.

Water in streams flowing through the lacustrine plain (geomorphic areas 1B and 1F) is of the calcium bicarbonate type and more mineralized than in the remainder of the region. Concentrations of bicarbonate are generally less than 180 parts per million. Iron contents are generally higher and colors are darker than limits recommended for domestic consumption. Water from peatlands is typically higher in iron and darker in color but lower in pH than water from areas of mineral soils.

[1]This information is based on Hydrologic Investigation Atlases HA 549, HA 551, and HA 556 (see water references at end of this publication).



Waterfalls are common along the North Shore of Lake Superior where streams flow down steep bedrock slopes before entering the lake.

Short Descriptions of Soil Series[2]

Ahmeek—Light-colored, well and moderately well-drained, strongly acid fine sandy loam about 16 inches over dark brown, medium to slightly acid fine sandy loam having weak fragipan. Dark reddish brown, neutral fine sandy loam glacial till occurs below about 60 inches. (Typic Fragiochrept)

Alluvial Land, undifferentiated—Consists of recent alluvium of variable texture and of variable drainage on flood plain. (Unclassified)

Barto—Light-colored, well-drained, strongly to medium acid gravelly coarse sandy loam 8 to 20 inches thick over bedrock. (Lithic Dystrochrept)

Baudette—Light-colored, moderately well-drained, slightly acid very fine sandy loam to silt loam, over medium acid to neutral, brown silty clay loam subsoil with calcareous lacustrine silt at depths of 18 to 24 inches. (Aquic Eutroboralf)

Beseman—Dark reddish brown to black, very poorly drained, very strongly acid, highly decomposed peat 16 to 51 inches thick over gray strongly acid loamy sediment. (Terric Borosaprist)

Blackhoof—Black, very poorly drained, medium acid organic soil 4 to 16 inches thick over reddish brown neutral loam, underlain at about 45 inches by reddish brown loamy glacial till. (Histic Humaquept)

Cathro—Black, neutral, very poorly drained muck or peat about 23 inches thick over grayish brown alkaline sandy loam mineral sediment. (Terric Borosaprist)

Cloquet—Light-colored, somewhat excessively drained, strongly acid sandy loam, about 14 inches thick, over strongly acid, reddish brown gravelly loamy coarse sand, underlain at about 36 inches by reddish brown slightly acid gravelly coarse sand. (Typic Dystrochrept)

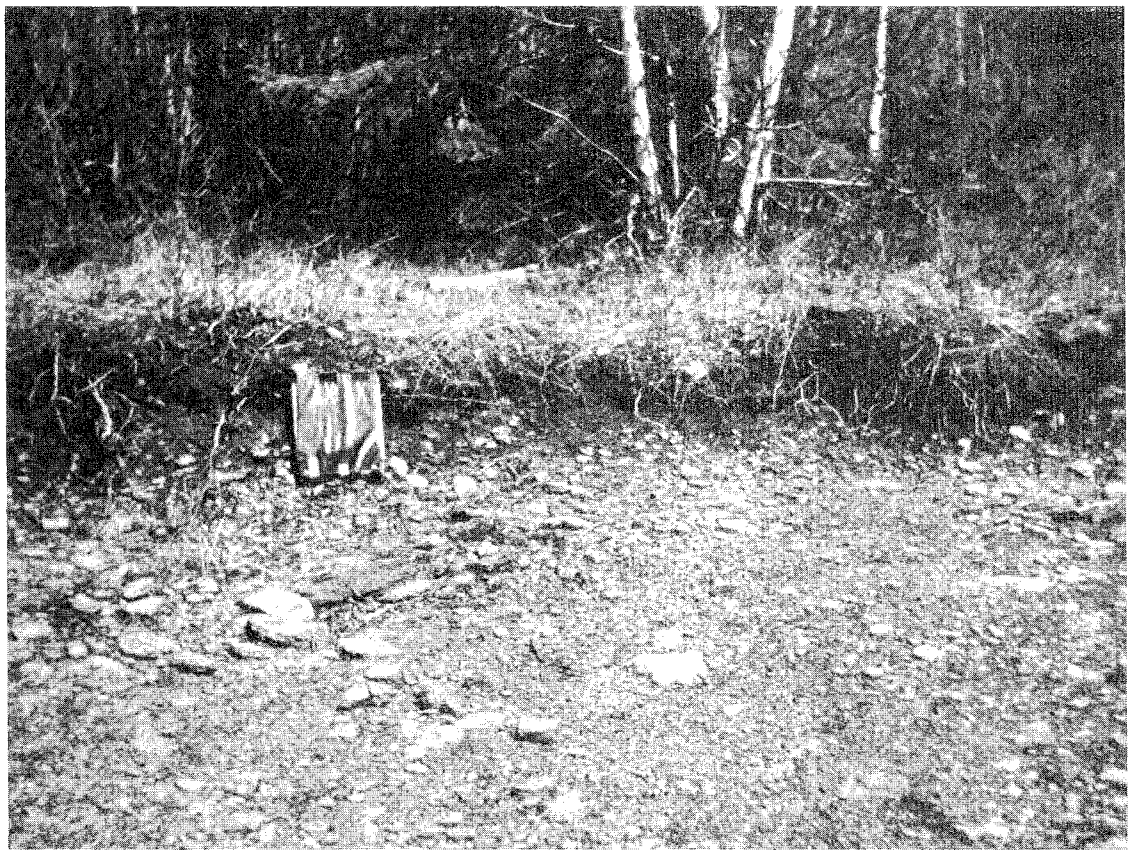
Conic—Light-colored, well-drained, strongly acid, gravelly sandy loam about 15 inches thick over dark brown, medium acid gravelly sandy loam with weak to strong fragipan. Bedrock occurs below 20 to 40 inches. (Typic Fragiochrept)

Cormant—Dark-colored, poorly to very poorly drained, neutral loamy fine sand about 6 inches thick over light brownish gray, neutral fine sand. (Mollic Psammaquent)

Dawson—Dark reddish brown, very poorly drained, extremely acid sphagnum moss about 8 inches thick over highly decomposed peat, underlain at 16 to 50 inches by grayish acid sandy sediment. (Terric Borosaprist)

Duluth—Light-colored, well and moderately well-drained, strongly acid very fine sandy loam about 18 inches thick over dark reddish brown, medium to slightly acid loam. Dark reddish brown, neutral loamy glacial till occurs below 42 to 80 inches. (Typic Eutroboralf)

[2]Following each description in parentheses is the classification of the series at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).



Rock fragments are common in this profile of the Barto series.

Dusler—Moderately dark to light-colored, somewhat poorly and poorly drained, strongly acid sandy loam and loam about 22 inches thick over reddish brown medium to slightly acid loam, underlain at 42 to 80 inches by reddish brown, neutral loamy glacial till. (Aeric Glossaquept)

Greenwood—Dark brown to dark reddish brown, very poorly drained, extremely to very strongly acid, moderately decomposed herbaceous peat more than 51 inches thick. (Typic Borohemist)

Grygla—Moderately dark-colored, poorly to somewhat poorly drained, medium acid fine sand 24 to 40 inches thick over calcareous loamy glacial till or lacustrine sediment. (Mollic Haplaquent)

Indus—Light-colored, poorly drained, slightly acid clay, about 12 inches thick over mildly to moderately alkaline clay underlain at about 24 inches by olive, strongly calcareous lacustrine clay or silty clay. (Typic Ochraqualf)

Insula—Light-colored, well-drained, medium to slightly acid gravelly sandy loam 8 to 20 inches thick over bedrock. (Lithic Dystrochrept)

Lobo—Dark brown and reddish brown, very poorly drained, extremely acid, slightly decomposed sphagnum peat about 38 inches thick over moderately decomposed herbaceous and sphagnum peat, commonly occurring on raised bog. The soil is usually more than 63 inches thick. (Hemic Sphagnofibrist)

Mahtowa—Dark-colored, poorly and very poorly drained, slightly acid to neutral loam about 40 inches thick over reddish brown loamy glacial till. (Typic Haplaquoll)

Menahga—Light-colored, excessively drained, medium acid loamy sand and fine sand about 33 inches thick over brownish yellow, slightly acid to neutral loose sand. (Typic Udipsamment)

Mesaba—Dark brown, well-drained, slightly acid gravelly sandy loam about 9 inches thick over brown, medium acid, gravelly sandy loam derived from glacial till. Bedrock occurs at a depth of 20 to 40 inches. (Typic Dystrochrept)

Mooselake—Dark reddish brown, very poorly drained, medium acid, moderately decomposed organic soil mostly of wood origin and more than 51 inches thick. (Typic Borohemist)

Newfound—Light-colored, well-drained, strongly acid, gravelly sandy loam about 16 inches thick over yellowish brown, medium acid, gravelly sandy loam with well developed fragipan. The soil developed in glacial till having 15 to 35 percent coarse fragments. Bedrock commonly occurs at depths of more than 5 feet. (Typic Fragiochrept)

Omega—Light-colored, somewhat excessively drained, very strongly acid loamy sand about 10 inches thick over medium acid sand, underlain at about 22 inches by light reddish brown, neutral fine sand. (Spodic Udipsamment)

Ontonagon—Light-colored, moderately well-drained, medium acid, very fine clay 16 to 33 inches thick over reddish brown calcareous lacustrine very fine clay. (Typic Eutroboralf)

Ontonagon (shallow over bedrock)—Light-colored, moderately well-drained, medium acid, very fine clay 20 to 40 inches thick over bedrock. (Typic Eutroboralf)

Quetico—Light-colored, somewhat excessively drained, very strongly acid loam 4 to 8 inches thick over bedrock. (Lythic Udorthent)

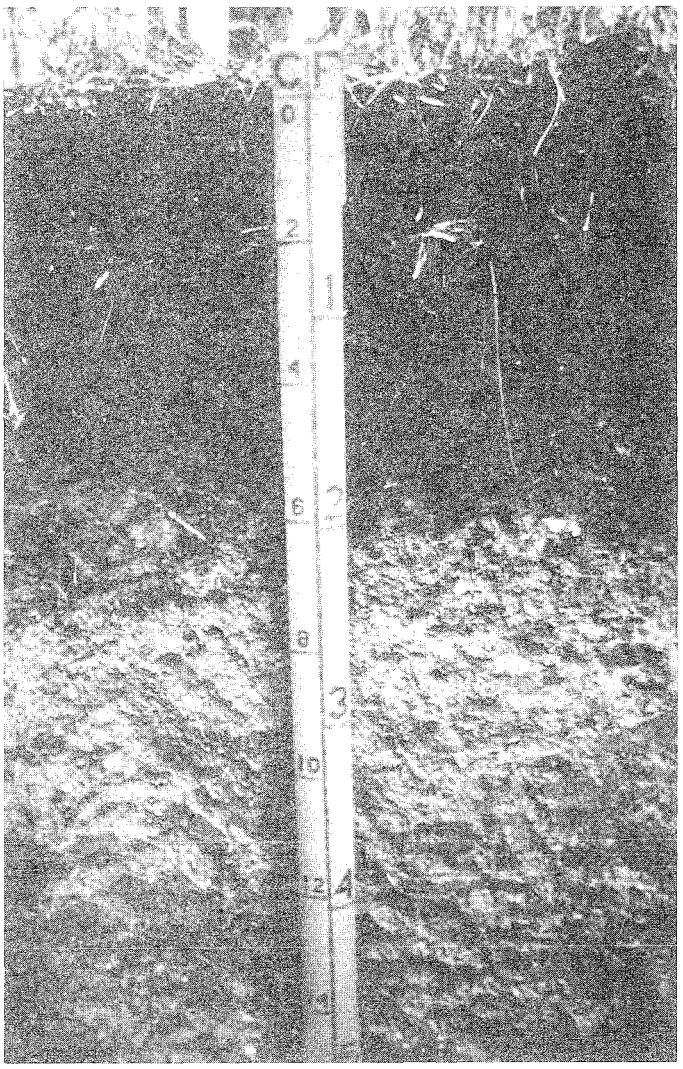
Seelyeville—Dark-colored, very poorly drained, medium acid to neutral muck about 16 inches thick, over very dark brown, medium acid to neutral peat to depths of 51 inches or more. The fibers are mostly derived from herbaceous plants. (Typic Borosaprist)

Taylor—Light-colored, moderately well and well-drained, slightly acid loam surface about 8 inches thick over silty clay or clay subsoil, underlain at about 22 inches by strongly calcareous lacustrine clay. (Aquic Eutroboralf)

Toivola—Light-colored, excessively drained, medium acid, very gravelly coarse sandy loam about 5 inches thick over dark brown, strongly acid, very gravelly loamy coarse sand. Slightly acid, very gravelly coarse sand occurs below 16 to 35 inches. (Typic Udorthent)

Washkish—Brown and reddish brown, very poorly drained, slightly decomposed, extremely acid organic soil on large raised bogs primarily derived from sphagnum moss. (Typic Sphagnofibrist)

Wildwood—Dark-colored, very poorly drained, slightly acid organic soil up to 12 inches thick over silty clay or clay about 25 inches thick underlain by calcareous olive gray lacustrine clay. (Histic Humaquept)



Dark organic soil material comprises the upper twelve inches of the Wildwood series.

Glossary

Acid peat—Defined in this report as an organic soil having a pH less than 5.5 See non-acid peat.

Available water-holding capacity—The capacity to store water available for use by plants, usually expressed in linear depths of water per unit depth of soil.

Bedrock—The more or less solid rock in place either on or beneath the surface of the earth.

Calcareous—Material containing sufficient calcium carbonate to effervesce visibly when treated with cold 0.1 normal hydrochloric acid.

Drainage, soil—As a natural condition of the soil, soil drainage refers to the frequency and duration of periods when the soil is not saturated with water. Six classes of natural drainage are recognized in this report.

- Excessively drained soils are commonly very porous and highly permeable (sandy and gravelly) and have a low available waterholding capacity.
- Well-drained soils are nearly free from mottling and are commonly of intermediate texture.
- Moderately well-drained soils commonly have a layer of moderate or low permeability in or immediately beneath the rooting zone. They have uniform color in the upper rooting zone and are mottled below 16 to 20 inches.
- Somewhat poorly drained soils are wet for significant periods, and are commonly mottled below a depth of 6 to 16 inches.
- Poorly drained soils are wet for longer periods. They are dark gray or black and are generally mottled within a depth of 18 inches. In some soils, mottling may be absent or nearly absent.
- Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling in the rooting zone below the surface soil.

Drift, glacial—Rock and mineral debris transported by glaciers and deposited either directly by the ice or from the meltwater. The debris may or may not be heterogeneous.

Drumlin—A streamlined (cigar-shaped) hill of glacial drift with the long axis parallel to the direction of the flow of the glacier.

Esker—A narrow ridge of gravelly or sandy drift deposited by a stream in association with glacial ice.

Fragipan—A subsoil layer, somewhat compacted or cemented, which restricts downward movement of water.

Ground moraine—Glacial debris consisting chiefly of unsorted material that occurs over areas and has a gently irregular surface. The debris is deposited underneath and at the margin of a glacier during the active recession of the ice sheet.

Herbaceous—Pertaining to flowering plants whose stem above ground does not become woody.

Ice-contact—Outwash material deposited adjacent to a mass of glacial ice. A steep slope forms at the zone of contact when the ice melts.

Lacustrine deposit—Material deposited in lake water and later exposed by lowering of the water level.

Limy—See calcareous.

Loess—Material transported and deposited by wind and consisting primarily of silt-sized particles.

Meltwater—The water which flows on, in, or out from a glacier.

Mineral soil—A soil consisting predominantly of, and having its properties determined predominantly by mineral matter, usually containing less than 20 percent organic matter but sometimes containing an organic surface layer up to 12 inches thick. See organic soil.

Moraine—Unconsolidated rock and mineral debris deposited by glacial ice. It commonly consists of a heterogeneous mass of material, but that deposited by glacial meltwater is sorted. See ground moraine and terminal moraine.

Mottled soil—Soil irregularly marked with spots of color, commonly caused by impeded drainage.

Non-acid peat—Defined in this publication as an organic soil having a pH of 5.5 to 7.0. See acid peat.

Organic soil—A soil that contains a high percentage (greater than 20 or 30 percent) of organic matter. See mineral soil.

Outwash plain—A plain of sorted and stratified sand and gravel deposited by glacial meltwater.

Peat—A dark brown or black residuum produced by the partial decay of plants growing in wet environments.

Permeability—The ability of the soil to transmit air or water.

pH, soil—A numerical measure of the acidity or hydrogen ion activity of a soil. See reaction, soil.

Reaction, soil—The degree of acidity or alkalinity of soil expressed in pH values or in words as follows:

	pH
Extremely acid	below 4.5
Very strongly acid	4.5-5.0
Strongly acid	5.1-5.5
Medium acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Mildly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	9.1 and higher

Relief—In geology, the difference in elevation between the highest and lowest points in the landscape.

Rooting zone—The part of the soil that is penetrated or can be penetrated by plant roots.

Stagnant ice—Glacial ice which does not flow actively.

Subsoil—Roughly, the part of the soil profile between the subsurface and the substratum.

Substratum—A layer beneath the subsoil consisting of material from which soils were formed, or frequently of dissimilar materials.

Subsurface—Soil layer immediately below the surface soil or plow layer, ranging from 6 to 12 inches thick.

Surface soil—Ordinarily the plow layer or the surface 5 to 12 inches.

Texture, soil—The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, as related to the three classes used in the report, follow:

S—sandy and loamy sand (also includes gravel).

L—sandy loam, loam, silt loam, silt, sandy clay loam, and clay loam.

C—silty clay loam, sandy clay, silty clay, and clay.

Terminal moraine—Glacial debris heaped in the form of a belt or zone of hills and basins at the terminus or margin of glacier. It marks the maximum extent of the ice during a major advance.

Till—Unstratified and unsorted glacial drift deposited directly by a glacier.

Undifferentiated soil group (mapping unit)—Two or more soils or land types mapped as one unit.

Water table—The upper surface of ground water or that level below which the soil is saturated with water.

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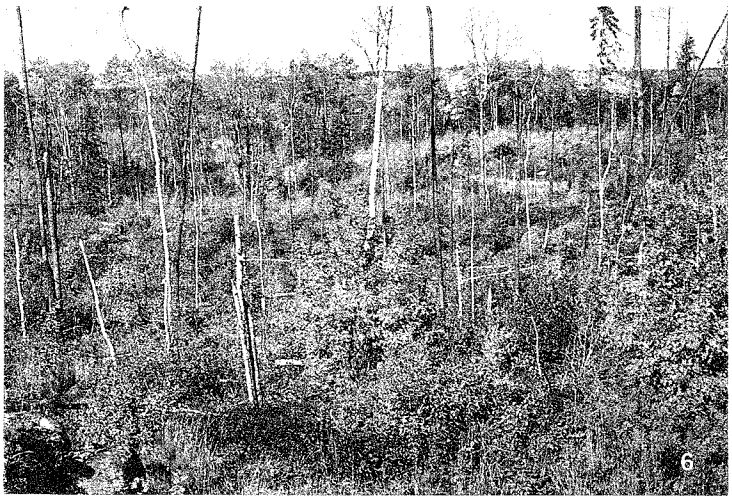

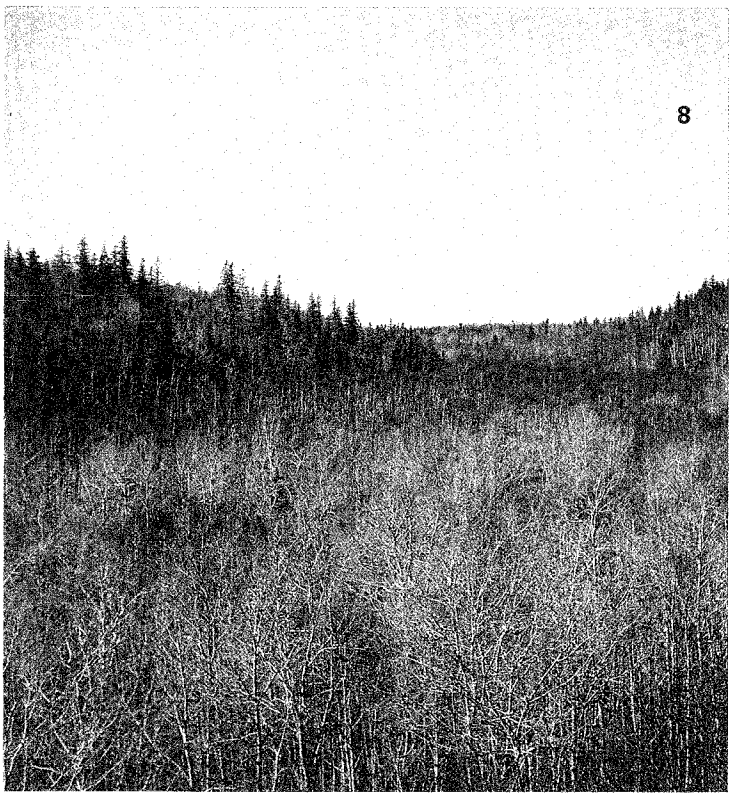

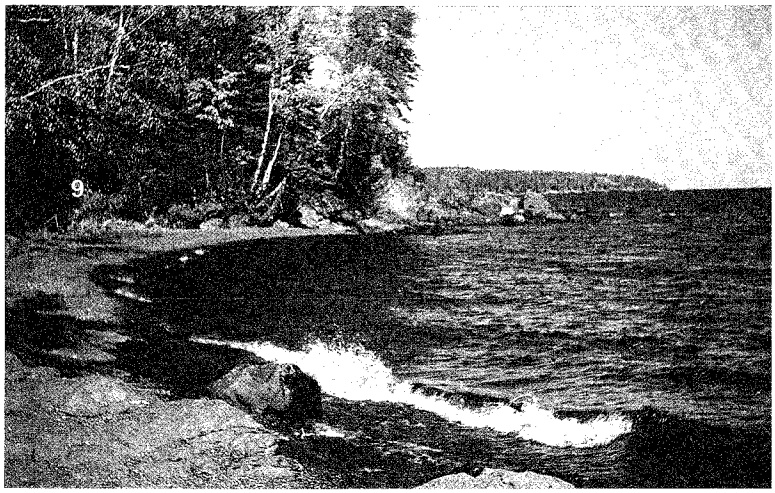

6. Sparse vegetation remains in a recently cutover area of soil landscape unit RLWL. 7. A thin loamy soil overlies bedrock in soil landscape unit RLWL which occurs extensively in the Tower-Ely Glacial Drift and Bedrock Complex (19) and the Highland Flutes (52B). 8. Typical setting of soil landscape unit CGWL (foreground) and RLWL (on hills) and in the Highland Flutes (52B). 9. A rocky, wooded coastline is characteristic of the North Shore of Lake Superior. 10. Forest residues have been freshly roller chopped in this clear-cut area of the Highland Moraine (52A).