SOIL SURVEY OF

Kawishiwi Area, Minnesota

Parts of Lake and Cook Counties in Superior National Forest

United States Department of Agriculture
Forest Service and Soil Conservation Service
In cooperation with
Minnesota Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey. It is a joint effort of the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the Minnesota Agricultural Experiment Station. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1967–69. Soil names and descriptions were approved in 1972. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing forested lands, recreational sites, watersheds, and wildlife areas.

All the soils of the Kawishiwi Area are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the Area in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be placed over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Foresters and others can refer to the section "Timber Management," where the soils of the area are grouped according to their suitability for trees.

Wildlife managers and others can find information about soils and wildlife in the section "Wildlife."

Resource planners and engineers can find, under "Engineering," a table that contains estimates of soil properties.

Scientists and others can read about the soils in the section "Genesis, Morphology, and Classification."

Broad patterns of soils are described in the section "General Soil Map," and other information about the Area is given in the section "Soil Landscape."

Contents

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Summary of Tables

SOIL SURVEY OF KAWISHIWI AREA, MINNESOTA
PARTS OF LAKE AND COOK COUNTIES IN SUPERIOR NATIONAL FOREST

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THE KAWISHIWI AREA: PARTS OF LAKE AND COOK COUNTIES IN SUPERIOR NATIONAL FOREST (hereafter referred to as the Kawishiwi Area) is in northeastern Minnesota east of Ely (fig. 1).
The survey area is in the extreme southern part of the Boreal Forest in the Souris-Red Rainy River Basin.

The Kawishiwi Area occupies 321,869 acres, 307,000 of which are accessible only by foot, watercraft, or aircraft. It consists of parts of the Kawishiwi, Halfway, Tofte, and Gunflint Ranger Districts of the Superior National Forest. Ninety percent of the Area is in the Boundary Waters Canoe Area, which is part of the National Preservation System, and is managed in accordance with the Shipstead-Newton-Nolan Act (PL 539), the Thye-Blatnik Act (PL 733), and the Humphrey-Thye-Blatnik-Anderson Act (PL 607).

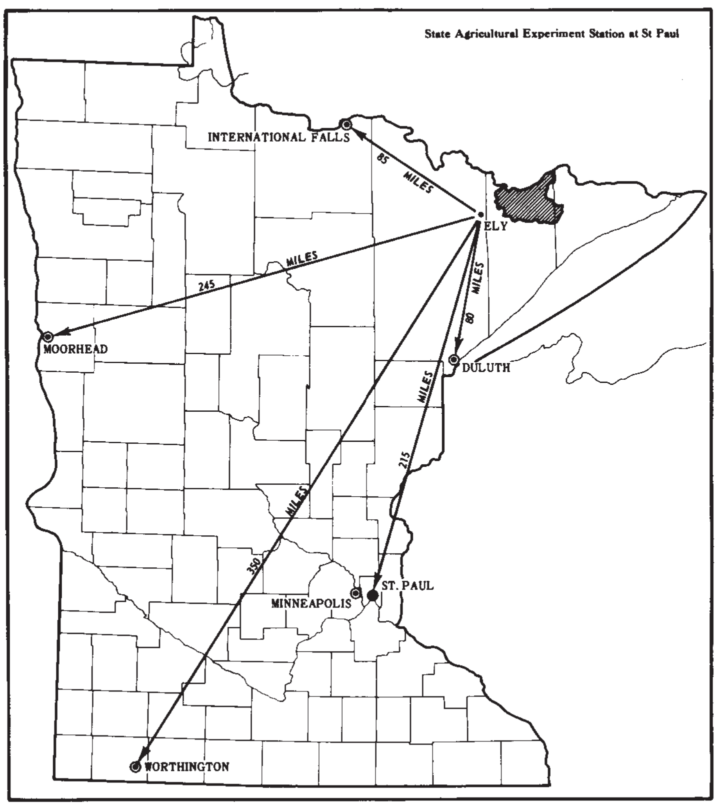

Figure 1.—**Location of the Kawishiwi Area in Minnesota.**

Two watersheds that form distinct natural soil resource areas make up the survey area: the Basswood-Knife Lake Watershed and the Kawishiwi Barometer Watershed. A barometer watershed is a representative landscape model for a given geographic area. Hydrologic data are collected from the barometer watershed and interpreted on an area basis.

Numerous lakes, many of which have interconnecting water systems, are in the Area. Lakes in the Basswood-Knife Lake Watershed commonly have clear water; those in the Kawishiwi Barometer Watershed typically have brownish water. Plentiful fish populations inhabit most lakes in both watersheds.

Wilderness, recreation, water, wildlife, and timber have historically been and still are the major resources of the Area. Man's activities in the Area have been related to these resources, but there now appears to be potential for extracting minerals from the Area.

Several research projects, including an ecological inventory of plant communities, user characteristics associated with canoeists, timber wolf studies, and moose habitat studies, are being conducted in the survey area. The instrumented barometer watershed continues to supply recorded hydrologic data.

How The Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in the Kawishiwi Area, where they are located, and how they can be used. They went into the Area knowing they likely would find many soils they had never seen and perhaps some they had. As they traveled over the Area, they observed steepness, length, and shape of slopes; size of streams; kinds of native plants; kinds of rock; and many facts about the soils. They dug or bored many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down to the relatively unaltered rock material (*7*).[1]

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in areas nearby and in places more distant. They classified and named the soils according to uniform procedures.

Soils with profiles having similar properties make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or a geographic feature near the place where a soil of that series was first observed and mapped. Barto and Insula, which are names of lakes in the survey area, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in natural characteristics.

After a fairly detailed guide for classifying and naming the soils had been worked out, the soil scientists drew soil boundaries on aerial photographs. These photographs show landscape features that greatly help in drawing boundaries accurately. The soil map in the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. A mapping unit is a delineation of a land area that is dominated by a soil series or a combination of series and that reflects a specific soil landscape feature pertinent to resource management and soil conservation. In this area, percentage of slope and the results of cultural activities form part of the criteria for delineation of mapping units.

In preparing some detailed maps, the soil scientist must delineate areas where different kinds of soils are so intricately mixed or of such limited extent that it is not practical to show them separately on the map. Therefore, he shows this mixture of soils as one mapping unit and calls it a soil complex. Ordinarily, a soil complex is named for the major soil series in it. An example is the Quetico-Rock outcrop complex, 5 to 18 percent slopes.

While a soil survey is in progress, samples of soils are taken for laboratory measurements and for engineering tests. But only part of a survey is done when the soils have been named, described, and delineated on the map and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way that it is readily useful to different groups of readers.

Support for this soil survey came from many sources. Initially, Forest Service (USDA) support triggered the project. After the project was activated, a cooperative work plan with the Minnesota Agricultural Experiment Station and the Soil Conservation Service was established. These cooperators supplied leaf-off photography, manpower, laboratory services, equipment and equipment use, soil classification and correlation, and publication of the survey.

I. Soil Landscape

In this section, the geology, climate, vegetation, and drainage of the Kawishiwi Area are described, and the importance of wildfire in the survey area is discussed.

Geology

The varied geology of the area is representative of the southern edge of the Laurentian Shield country. Multiple glaciation, which ended about 12,000 years ago, helped to reshape the surface configuration of the various bedrocks.

Precambrian bedrock formations prevail in this area of bedrock-controlled topography. Duluth-Gabbro complex dominates the Kawishiwi Barometer Watershed. This complex is mostly a group of undifferentiated anorthositic gabbroic rocks. Typically plagioclase is the main mineral, and interstitial minerals are augite, hypersthene, and olivine. Proportion, texture, and composition of these minerals are variable (*4*). Along the watershed boundary is a copper- and nickel-bearing rock. In the Basswood-Knife Lake Watershed, the dominant bedrock types are granite, slate, gneiss, and basalt.

Associated with the bedrock-controlled topography are numerous fault lines extending 5 to 15 miles in length, common bedrock escarpments ranging from 5 to 75 feet in height, and waterfalls flowing in crevasses and over rock ledges.

A mantle of Pleistocene glacial materials blanket most of the Area. These materials consist of till, outwash, and lacustrine deposits associated with the Wisconsin glacier (*9*). It is believed that the Rainy sublobe of the Carey lobe moved into the Area from the north and northeast, carrying with it materials from the Laurentian Shield country of Canada.

Climate

Northeastern Minnesota is dominated by a marked continental climate. Three main air masses prevail in the Area. Continental polar and artic air masses forming in or north of the Saskatchewan plains flow south into Minnesota and bring severe winter weather. Maritime tropical air masses forming in the Gulf Coast area move up the Mississippi Valley and supply northeastern Minnesota with most of its precipitation. Air masses moving east from the Rock Mountains and plains usually bring mild, dry weather to the Area.

Annual precipitation in the Superior National Forest ranges from 26 to 31 inches. Of this, about 60 percent falls between April 1 and November 1. About 40 percent of the precipitation is snow. Annual precipitation is generally greater in the eastern part of the survey area than in the western part, but this is subject to seasonal variations. Average annual snowfall is about 65 inches, and duration of snow cover of 1 inch or more is about 153 days.

The annual growing season ranges from 100 to 123 days. The last killing frost in the spring can be expected between May 22 and June 5, and the first in the fall occurs between September 10 and September 27. The average temperature is 42° F in spring, 68° in summer, 45° in fall, and 12° in winter. Annual cumulative growing degree days range from 2,600 to 3,200. Summer temperatures higher than 90° F and winter temperatures lower than –40° are not uncommon.

[1] Italic numbers in parentheses refer to Literature Cited, p. 30.

Vegetation

The vegetation in the survey area is representative of the extreme southern part of the Boreal Forest within the Laurentian Shield country of northeastern Minnesota. Stands of sawtimber (white and red pine) were common prior to 1920; however, logging and fire have now reduced these stands to isolated, scattered islands within the vegetative cover dominated by trembling aspen and jack pine.

Trembling aspen and jack pine (with an understory of spruce and fir in many places) are the dominant upland species. Black spruce and white-cedar dominate in lowland areas, including bogs. Black ash (associated with lacustrine deposits), red maple, and scrub oaks are common in the Basswood-Knife Lake Watershed but less common in the Kawishiwi Barometer Watershed. Shrubs common throughout the Area are beaked hazel, mountain maple, green alder, and speckled alder. White and red pine (sawtimber size) grow locally in natural stands. White-cedar grows primarily along lakeshores in the Kawishiwi Barometer Watershed. It is more common, however, in the Basswood-Knife Lake Watershed, where it also grows in the uplands. It is generally associated with lacustrine deposits and well decomposed and moderately decomposed organic soils.

Soil-vegetation relationships in the Basswood-Knife Lake Watershed are meaningful to the soil scientist. Such relationships are not so apparent in the Kawishiwi Barometer Watershed. Jack pine commonly occupies ridgetops in the Basswood-Knife Lake Watershed, where the shallow, droughty Quetico soils are common. Trembling aspen, white spruce, and balsam commonly occupy adjacent lower side slopes on Conic, Insula, Newfound, and Indus soils. White birch in nearly pure stands is commonly associated with the deep, coarse textured Well drained loamy and gravelly soils. In the swales and drainageways occupied by Indus soils and poorly drained silty and clayey soils, black ash, trembling aspen and white-cedar prevail. A cover of black spruce, white-cedar, and mixed shrubs dominates Mucky peats and Waskish soils. Grass and sedge meadows are associated with the Seelyeville soil.

The typical tree species common to the Area on well drained soils are:

Jack pine	*Pinus banksiana*
Eastern white pine	*Pinus strobus*
Red pine	*Pinus resinosa*
Trembling aspen	*Populus tremuloides*
Largetooth aspen	*Populus grandidentata*
Balsam poplar	*Populus balsamifera*
Paper birch	*Betula Papyrifera*
Balsam fir	*Abies balsamea*
White spruce	*Picea glauca*
Red maple	*Acer rubrum*
American basswood	*Tilia americana*

The typical tree species common to the Area on somewhat poorly drained to very poorly drained soils are:

Black spruce	*Picea mariana*
Tamarack	*Larix laricina*
White-cedar	*Thuja occidentalis*
Black ash	*Fraxinus nigra*

Shrubs and forbs common to the Area on well drained soils are:

American hazel	*Corylus americana*
Beaked hazel	*Corylus cornuta*
Mountain maple	*Acer spicatum*
Serviceberry	*Amelanchier bartramiana*
Redosier dogwood	*Cornus stolonifera*
Alternate-leaf dogwood	*Cornus alternifolia*
Dwarf bushhoneysuckle	*Diervilla lonicera*
Canada honeysuckle	*Lonicera canadensis*
Pin cherry	*Prunus pensylvanica*
Dwarf juniper	*Juniperus communis*
Bracken fern	*Pteridium aquilinum*
Interrupted-fern	*Osmnuda claytoniana*
Woodfern	*Dryopteris spinulosa*
Goldenrod	*Solidago spp.*
Wild red raspberry	*Rubus strigosus*
Sour-top blueberry	*Vaccinium myrtilloides*
Thimbleberry	*Rubus parviflorus*
Sarsaparilla	*Aralia nudicaulis*
Rosy twistedstalk	*Streptopus roseus*
Bigleaf aster	*Aster macrophyllus*
Bunchberry	*Cornus canadensis*
Yellow clintonia	*Clintonia borealis*
American starflower	*Trientalis borealis*
Princespine	*Chimaphila unbellata*
Canada mayflower	*Maianthemum canadense*

Shrubs and forbs common to the Area on somewhat poorly drained and poorly drained soils are:

Willow	*Salix spp.*
Hazel alder (speckled alder)	*Alnus rugosa*
American green alder	*Alnus crispa*
Dwarf birch	*Betula glandulosa*
Labradortea	*Ledum groenlandicum*
Leatherleaf	*Chamaedaphne calyculata*
Spiraea	*Spiraea spp.*
Bog-rosemary	*Andromeda glaucophylla*
Wild iris	*Iris versicolor*
Pitcherplant	*Sarracenia purpurea*
Small cranberry	*Vaccinium oxycoccos*
Lowbush blueberry	*Vaccinium angustifolium*

Grasses common to the Area on well drained soils are:

Redtop	*Agrostis alba*
Bluejoint reedgrass	*Calamagrostis canadensis*
Quackgrass	*Agropyron repens*
Poverty grass	*Danthonia spicata*
Drooping woodreed	*Cinna latifolia*
Canada wildrye	*Elymus canadensis*
Falsemelic	*Schizachne purpurascens*
Bearded shorthusk	*Brachyelytrum erectum*
Roughleaf ricegrass	*Oryzopsis asperifolia*

Grasses or related species common to the Area on somewhat poorly drained and poorly drained soils are:

Cottonsedge	*Eriophorum spp.*
Rice cutgrass	*Leersia oryzoides*
Cattail	*Typha latifolia*
Sedge	*Carex spp.*

Mosses, clubmosses, lichens, and liverworts common to the Area are:

Sphagnum	*Sphagnum spp.*
Hypnum	*Hypnum spp.*
Runningpine	*Lycopodium clavatum*
Groundpine	*Lycopodium obscurum*
Reindeermoss	*Cladonia spp.*
Spotted peltigera	*Peltigera aphthosia*
Conocephale	*Conocephalim conicum*
Marchantia	*Marchantia polymorpha*

Wildfire

Wildfire has played an important role in the vegetative history of the Area (*1*). Apparently, more recently burned areas (fig. 2) contain more nearly pure stands of either trembling aspen or jack pine. In older burned areas, there is typically a mixture of aspen and jack

***Figure 2.*—Fire has played an important role in the history of the Kawishiwi Area. Controlled, it can be a useful resource management tool.**

pine with an understory of balsam fir and white or black spruce.

Charcoal is common throughout the Kawishiwi Area. It is typically at the point of contact of the surface organic material and the underlying mineral soils. Also, bands of charcoal are in several organic soils, and it is not uncommon for several bands to be in a given organic soil profile. Charred pine stumps and logs were observed in the Area.

Drainage

The natural drainage pattern in the Kawishiwi Area is complex and mixed. A youthful drainage system with dendritic and rectangular drainage patterns —and modifications of these patterns—prevails in the Area. Water from the survey area (which is near the Laurentian Divide) flows westerly and northerly into the Rainy Lake Watershed and eventually into Hudson Bay.

Elevation in the survey area ranges from 1,320 to 1,640 feet—from 1,320 to 1,640 feet in the Basswood-Knife Lake Watershed, and from 1,520 to 1,620 feet in the Kawishiwi Barometer Watershed.

Ridges and valleys in the Basswood-Knife Lake Watershed are prominently oriented in a northeast-southwest direction. However, in the Kawishiwi Barometer Watershed, there is a strongly mixed pattern of arch-shaped ridges, elongated north-south fault lines, and some east-west ridges and valleys. The Kawishiwi Barometer Watershed expresses a distinct basin effect, and the Basswood-Knife Lake Watershed does not.

II. Soil Resources

The gently sloping to steeply sloping soils of the area formed mainly in glacial till, outwash, and lacustrine sediment. These rocky and stony soils are shallow over bedrock. Except for the fine textured lacustrine sediment, the deposits are coarse textured and moderately coarse textured and have a high content of gravel and cobbles. Typically, the soils that formed in these coarser deposits are well drained. Those that formed in the lacustrine silts and clays are poorly drained to somewhat poorly drained. Deposits of glacial till and outwash are in both watersheds. The lacustrine deposits, however, are present only in the western two-fifths of the Basswood-Knife Lake Watershed.

Genesis, Morphology, and Classification

Five major factors influence the genesis or formation of soil (*5*). They are climate, living organisms, parent material, topography, and time. The characteristics of any given soil represent a combined effect of these factors.

Climate and living organisms are active forces that form soil. Their actions change the accumulated material into distinguishable layers called horizons. The composition of the parent material strongly influences the kind of soil that can be formed. Topography, or relief, influences the effect of temperature and moisture. The length of time a soil has been developing is reflected in the thickness of the soil and the differences in the layers of the profile.

Snow covers the area from about November through mid April. Frost typically develops before snow cover and persists throughout the winter. The depth of frost, however, is reduced after a continuous snow cover develops. Sometimes, the frost is reduced from several feet to a few inches thick as snow cover develops, and then increases slightly during spring breakup. At that time, the snow cover is removed, but temperatures frequently dip below freezing for prolonged periods.

Precipitation has its greatest effect during the periods of spring breakup and fall recharge. During these periods, the uptake of moisture by plants is at a minimum, and water moves vertically through the soil. This water can transport materials to the lower part of the profile. Little water moves beyond the root zone during the growing season. Also, where soils are less than 40 inches deep over bedrock, there is little opportunity for deep percolation of moisture.

Plants, small animals, and micro-organisms help in the development of soils. Plants return nutrients to the soil as fallen leaves and dead roots decompose. Acids from the decomposing plant material leach through the soil and influence the movement of aluminum, iron, and organic matter. Small animal holes and channels provide for entry of water, plant parts, and air. Micro-organisms decompose accumulations of plant and animal remains on the surface and in the soil.

The parent material consists of glacial till, outwash, lacustrine sediment, and organic soil material, and there is some evidence of windblown material. Wisconsin glacial till dominates the Area. Generally there are two kinds of till—one is yellowish brown and the other is reddish brown. Till is generally less than 40 inches thick over bedrock. The yellowish brown till dominates the northern half of the survey area, and the reddish-brown till prevails in the southern half. Outwash material, typically more than 40 inches deep, is common in the west-central part of the Area. Lacustrine deposits are in the northwestern part of the Area in upland flats and gently sloping lowlands adjacent to bodies of water. Organic materials throughout the Area occupy former lake basins, drainageways, and upland swales.

Variations in topography influence soil development by affecting the degree of drainage and erosion. On steep slopes the surface and subsurface moisture is removed rapidly, and the surface soil undergoes frequent wetting and drying cycles. Undulating slope conditions favor moisture retention and reduce the frequency of wetting and drying cycles. Steep soils have less organic matter in the profile than undulating soils because of the moisture relationship and erosion. Erosion is not a major factor in undisturbed areas because of the nearly continuous vegetative cover and the organic layer.

Since only about 12,000 years have elapsed since the last glacier covered the Area, the soils are considered to be young. However, horizonation is well expressed in the soils, and there is evidence of movement of fine material in some soils.

The morphological properties of soils are the products of the combined effect of the soil forming factors. In this section some of the processes that affect soil morphology are mentioned, and the morphology of a representative profile of each series is described. Soil morphology in the Kawishiwi Area generally is expressed by a well developed B horizon. Most soils have prominent horizons within the profile.

Horizon differentiation can be attributed mainly to one or more of the following processes: accumulation of organic matter, leaching of soluble constituents, translocation of silicate clay material, and reduction and transfer of aluminum and iron. In most soils, two or more of these processes were involved.

Organic matter has accumulated in the surface horizon (B21hir) of the Barto and Mesaba soils. An A1 horizon, uncommon in the Area, is mainly in poorly drained soils.

The leaching of carbonates and soluble minerals has occurred at a varying rate in most soils. Most soils are more alkaline with depth; this indicates downward movement of carbonates.

The effects of leaching on horizon differentiation are indirect because leaching permits the translocation of silicate clay minerals in some soils. The leaching of iron, aluminum, and other soluble minerals from the surface layer has been important in differentiating the horizons of some forest soils. In these soils, a light-colored A2 (albic) horizon, low in organic matter, aluminum, and iron has formed. This is characteristic of Conic and Newfound soils.

Translocation of silcate clay minerals has affected the Indus soil and, to a lesser degree, the Conic soil. This movement of clay from the A2 horizon to the B horizon is evident by the presence of clay films on some ped faces in the B horizon. These clay films are lighter colored in most places than the ped interiors. Also, there is evidence of clay movement along some root channels.

Reduction and transfer of iron has occurred in the poorly drained and somewhat poorly drained soils. These processes have resulted in mottling and gleying. The poorly drained soils are reddish, brownish, or yellowish in most places, and the somewhat poorly drained soils are greenish, bluish, or grayish.

Soils are classified so they can be readily identified and so knowledge about them can be organized and applied to areas of only a few acres or to areas as large as a state or a continent. A new system, known as the Soil Taxonomy of the National Cooperative Soil Survey, is currently in effect (*8*). Readers interested in the development of the system can refer to recent publications. In table 1, the soils of the Kawishiwi Area are classified according to the current system.

Descriptions of the Soils

The basic unit of soil classification is the soil series. The properties of all soils within a series are essentially alike. The basic unit of the soil survey is the mapping unit, which primarily represents a soil series in its various forms on the terrain. Different mapping units within a series can have different properties, but they are dominated by the properties of their series. A mapping unit is comparable to a timber type, and a soil map is comparable to a timber type map.

On the following pages are series descriptions, associated mapping unit descriptions, and the capability classification of each mapping unit. For each series, a soil profile representative of the series is described. Differences between the profile of any mapping unit and the profile described as representative of the series are given in the description of the mapping unit, or they are apparent in the name of the mapping unit.

In table 2, the approximate acreage and proportionate extent of each mapping unit in the survey area are listed. See the section "Capability Grouping" for an explanation of the capability classification system.

TABLE 1.—*Classification of the soils*

[The soils are classified according to the Soil Taxonomy of the National Cooperative Soil Survey (*8*)]

Series or other taxonomic unit	Taxonomic class
Barto	Loamy, mixed, frigid, Lithic Dystrochrepts.
Conic	Coarse-loamy, mixed, frigid, Typic Fragiochrepts.
Indus [1]	Very fine, montmorillonitic, frigid, Typic Ochraqualfs.
Insula	Loamy, mixed, frigid, Lithic Dystrochrepts.
Mesaba	Coarse-loamy, mixed, frigid, Typic Dystrochrepts.
Mucky peats	Euic, Borohemists.
Newfound	Coarse-loamy, mixed, frigid, Typic Fragiochrepts.
Poorly drained loamy soils.	Loamy, Aquic Dystrochrepts and Histic Humaquepts.
Quetico	Loamy, mixed, frigid, Lithic Udorthents.
Seelyeville	Euic, Typic Borosaprists.
Waskish	Dysic, Typic Sphagnofibrists.
Well drained loamy and gravelly soils.	Loamy, Dystrochrepts; and sandy-skeletal, Udorthents.

[1] The Indus soil in the survey area is a taxadjunct to the Indus series. This soil has less clay and more silt than defined in the range for the Indus series. However, this difference does not appreciably affect its use and management.

Barto series

The Barto series consists of well drained, sloping to steep soils that formed in loamy material 8 to 20 inches thick over bedrock. These soils have complex slopes on bedrock-controlled terrain.

These soils typically have a thin surface layer of mostly decomposed plant remains over a subsoil of reddish brown, yellowish red, and strong brown gravelly loam, gravelly loamy coarse sand, and gravelly coarse sandy loam. The subsoil has an accumulation of organic matter and iron and aluminum oxides.

Permeability is moderately rapid, and available water capacity is very low. The soil is unstable during the spring thaw. Shallowness to bedrock, coarse fragments, and slope cause low to moderate water storage capacity and moderate to high water yield potential.

Use of the soils is limited by the shallow depth to bedrock, droughtiness, and slope. Engineering uses are limited by depth to bedrock and slope. Recreational uses of the soils are limited, and use of the soils for standard septic tank systems is severely limited. Low productivity, windthrow hazard, and droughtiness limit timber production. Wildlife habitat can be developed in some natural openings, and developed food plots respond satisfactorily to fertilization.

Vegetation common to these soils is an overstory of trembling aspen and jack pine. Shrubs are mainly beaked hazel, bushhoneysuckle, and green alder. Common forbs are bigleaf aster, sarsaparilla, bunchberry, and Canada mayflower.

Representative profile of Barto gravelly coarse sandy loam, 2 to 18 percent slopes, in a forested area in the NE¼NE¼SW¼ sec. 31, R. 7 W., T. 64 N.:

O1—2 inches to 1 3/4; undecomposed and decomposing plant remains.

O2—1 3/4 inches to 0; very dark gray (N 3/0) mostly decomposed plant remains; very strongly acid.

B21hir—0 to 2 inches; reddish brown (5YR 4/3) gravelly loam; weak fine and medium subangular blocky structure and weak fine and medium granular structure; friable; about 20 percent coarse fragments; strongly acid; clear smooth boundary.

B22hir—2 to 8 inches; yellowish red (5YR 4/6) gravelly loamy coarse sand; weak fine subangular blocky structure and weak fine and medium granular structure; friable; about 20 percent coarse fragments; strongly acid; clear smooth boundary.

B23—8 to 13 inches; yellowish red (5YR 4/8) gravelly coarse sandy loam; weak fine subangular blocky structure and weak fine granular structure; friable; about 20 percent coarse fragments; medium acid; clear smooth boundary.

B3—13 to 15 inches; strong brown (7.5YR 5/6) gravelly coarse sandy loam; weak fine and medium granular structure; friable; about 20 percent coarse fragments; medium acid; abrupt smooth boundary.

Depth to bedrock, which is mostly gabbro or granite, ranges from 8 to 20 inches. Coarse fragments cover 0 to 5 percent of the surface and make up 10 to 35 percent of the solum. On the surface they are mostly stones; in the solum they are mostly gravel and cobbles. The B horizon is mostly gravelly loam, loam, gravelly coarse sandy loam, coarse sandy loam, gravelly sandy loam, or sandy loam. In places, however, some subhorizons are gravelly loamy sand or gravelly loamy coarse sand. Reaction in the B horizon is commonly medium acid or strongly acid, but it ranges from very strongly acid to slightly acid.

Barto soils are commonly associated with Quetico and Mesaba soils and Poorly drained loamy soils. In the north-

TABLE 2.—*Approximate acreage and proportionate extent of the soils*

Map symbol	Mapping unit	Acres	Percent
BAC	Barto gravelly coarse sandy loam, 2 to 18 percent slopes	43,760	13.6
BAC2	Barto gravelly coarse sandy loam, 2 to 18 percent slopes, disturbed	9,436	2.9
BAE	Barto gravelly coarse sandy loam, 18 to 35 percent slopes	9,648	3.0
COC	Conic gravelly sandy loam, 2 to 18 percent slopes	24,654	7.7
COE	Conic gravelly sandy loam, 18 to 35 percent slopes	3,111	1.0
ID	Indus silty clay	1,866	.6
ISC	Insula gravelly sandy loam, 2 to 18 percent slopes	12,741	4.0
ISC2	Insula gravelly sandy loam, 2 to 18 percent slopes, disturbed	1,115	.3
ISE	Insula gravelly sandy loam, 18 to 35 percent slopes	2,068	.6
MEC	Mesaba gravelly sandy loam, 2 to 18 percent slopes	58,436	18.2
MEC2	Mesaba gravelly sandy loam, 2 to 18 percent slopes, disturbed	425	.1
MEE	Mesaba gravelly sandy loam, 18 to 35 percent slopes	23,970	7.4
MP	Mucky peats	22,961	7.1
NFC	Newfound gravelly sandy loam, 2 to 18 percent slopes	3,635	1.1
NFE	Newfound gravelly sandy loam, 18 to 25 percent slopes	322	.1
PD	Poorly drained loamy soils	15,659	4.9
QRC	Quetico-Rock outcrop complex, 5 to 18 percent slopes	10,239	3.2
QRE	Quetico-Rock outcrop complex, 18 to 35 percent slopes	5,198	1.6
RL	Rubble land	277	.1
SE	Seelyeville muck	4,904	1.5
WA	Waskish peat	1,165	.4
WD	Well-drained loamy and gravelly soils	5,475	1.7
	Water	60,804	18.9
	Total	321,869	100.0

ern half of the Area, they are also associated with Conic and Insula soils. Barto soils are deeper over bedrock than Quetico soils. They are not so deep as Conic and Mesaba soils. Barto soils have redder hues in the B horizon than similar Insula soils, and they do not have the A2 horizon of Insula soils.

BAC—Barto gravelly coarse sandy loam, 2 to 18 percent slopes. This sloping soil is mostly on irregular ridgetops and upper side slopes in irregular and broken terrain. In places it is bordered by lowland soils and drainageways. This soil has the profile described as representative of the series.

Included with this soil in mapping were small areas of Mesaba soils in midslope positions and Poorly drained loamy soils in depressions. Also included, in places, were outcrops of bedrock along ridgetops, lower side slopes, and escarpments.

This soil has low to moderate water storage capacity and water yield potential because of shallowness to bedrock and coarse fragment content. Capability subclass VIs.

BAC2—Barto gravelly coarse sandy loam, 2 to 18 percent slopes, disturbed. This sloping soil is on irregular ridgetops and side slopes. It has a profile similar to the one described as representative of the series, except the upper 3 to 8 inches has been removed as a result of cultural practices, which are activities associated with past land management.

Included with this soil in mapping were small areas of Mesaba soils in midslope positions and Poorly drained loamy soils in depressions. Also included, in places, were outcrops of bedrock along ridgetops, lower side slopes, and escarpments.

Because of the loss of the upper 3 to 8 inches of soil material, water storage capacity is low. Water yield potential is high. The hazard of erosion is higher in this soil than in the soil described as representative of the series, however, because surface organic material has been lost. Capability subclass VIs.

BAE—Barto gravelly coarse sandy loam, 18 to 35 percent slopes. This steep soil is on middle and lower side slopes in an irregular and broken landscape. It has a profile similar to the one described as representative of the series, except the surface layer and subsoil are thinner.

Included with this soil in mapping were small areas of Mesaba soils. Bedrock outcrops are more common along drainageways and escarpments than in other places. Also included were a few areas of stony soils.

Because the surface organic layer is thin and slopes are steep, surface runoff is high and water storage capacity is low. Water yield potential is high. Capability subclass VIIs.

Conic series

The Conic series consists of well drained, sloping to steep soils that formed in loamy material 20 to 40 inches thick over bedrock. These soils are on side slopes of bedrock-controlled terrain.

These soils typically have a thin organic surface layer over a thin light brownish gray subsurface layer. The upper part of the subsoil is dark brown to light yellowish brown and has an accumulation of organic matter and iron and aluminum oxides. The lower part of the subsoil is a light yellowish brown fragipan. These soils typically are gravelly sandy loam throughout.

Permeability is slow, and available water capacity is low. Coarse fragments, fragipan, and depth to bedrock cause moderate to low water storage capacity and water yield potential.

Use of the soils is mostly limited by moderate depth to bedrock and steep slopes. Engineering uses are limited by depth to bedrock and slope. Recreational uses are limited, and use of the soils for standard septic tank systems is severely limited. Timber production is limited by restricted root development, windthrow hazard, and seasonal droughtiness. Managed wildlife openings are feasible. Natural stands of wildlife foods are dense and varied in many places. The soils respond adequately to fertilization in developed food plots.

Common overstory vegetation on these soils is jack pine and trembling aspen. Shrubs are mainly beaked hazel, bushhoneysuckle, blueberry, and redosier dogwood. Common forbs are bigleaf aster, sarsaparilla, bunchberry, and Canada mayflower.

Representative profile of Conic gravelly sandy loam, 2 to 18 percent slopes, in a forested area in the NE1/4NE1/4NE1/4 sec. 31, R. 8 W., T. 64 N.:

O1—1 1/2 inch to 1; undecomposed and decomposing plant remains.

O2—1 inch to 0; black (5YR 2/1) and dark reddish brown (5YR 2/2) mostly decomposed plant remains; strongly acid.

A2—0 to 2 inches; light brownish gray (10YR 6/2) gravelly sandy loam; weak fine subangular blocky structure; friable; about 30 percent coarse fragments; very strongly acid; abrupt smooth boundary.

B21hir—2 to 6 inches; dark brown (7.5YR 4/4) gravelly sandy loam; weak fine subangular blocky structure and weak medium granular structure; friable; about 30 percent coarse fragments; strongly acid; clear smooth boundary.

B22ir—6 to 9 inches; yellowish brown (10YR 5/4) gravelly sandy loam; weak fine subangular blocky structure and weak fine granular structure; friable; about 30 percent coarse fragments; strongly acid; clear smooth boundary.

B23—9 to 15 inches; light yellowish brown (10YR 6/4) gravelly sandy loam; weak fine subangular blocky structure and weak fine granular structure; about 30 percent coarse fragments; friable; medium acid; clear smooth boundary.

Bx1—15 to 20 inches; light yellowish brown (10YR 6/4) gravelly sandy loam; weak medium platy structure parting to moderate fine subangular blocky; firm; weakly cemented; common fine vesicular pores; about 25 percent coarse fragments; medium acid; clear smooth boundary.

Bx2—20 to 26 inches; yellowish brown (10YR 5/4) gravelly sandy loam; weak medium platy structure parting to moderate medium subangular blocky; firm; weakly cemented; about 25 percent coarse fragments; medium acid; abrupt smooth boundary.

B3—26 to 30 inches; yellowish brown (10YR 5/4) gravelly sandy loam; weak fine granular structure; friable; about 30 percent coarse fragments; medium acid; abrupt smooth boundary.

R—30 inches; granite bedrock.

The fragipan ranges from 4 to 12 inches in thickness. Its upper part is at a depth of 10 to 20 inches. Depth to bedrock, mostly igneous but some metamorphic rock, ranges from 20 to 40 inches. The content of coarse fragments ranges from 20 to 35 percent. Coarse fragments are mainly pebbles, but in some areas stones make up a significant part of the mass. Textures in the solum include sandy loam, fine sandy loam, loam, coarse sandy loam, and gravelly phases of these, or silt loam. Reaction in the solum ranges mostly from very strongly acid to medium acid but is extremely acid in places.

Conic soils are primarily associated with Insula soils and Poorly drained loamy soils. In the northern part of the Area, they are also associated with Barto and Mesaba soils. They are deeper over bedrock than Barto and Insula soils. Conic soils have a fragipan, which similar Mesaba soils do not have.

CoC—Conic gravelly sandy loam, 2 to 18 percent slopes. This sloping soil is mostly on mid and upper side slopes but is also on ridgetops in some areas. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of Insula soils on upper slopes and ridgetops and Mesaba soils on mid and lower slopes.

This soil has low to moderate water storage capacity and high water yield potential because of depth to bedrock and fragipan and coarse fragment content. Depth to bedrock and low available water capacity are the main limitations to use. Capability subclass IVs.

CoE—Conic gravelly sandy loam, 18 to 35 percent slopes. This soil is on lower slope positions commonly adjacent to drainageways dominated by poorly drained soils. This soil has a profile similar to the one described as representative of the series, but it is thinner and coarse fragments are more common on the surface and in slightly higher concentrations throughout the soil.

Included with this soil in mapping were small areas of Mesaba soils. Also included were bedrock outcrops along drainageways and escarpments and a few stony areas.

Because the organic surface layer is thinner and slopes are steeper, surface runoff is higher and water storage capacity is low. Water yield potential is high.

Steep slopes, moderately deep soils, droughtiness, and erosion hazard are major limiting factors. Capability subclass VIIe.

Indus series

The Indus series consists of somewhat poorly drained, nearly level soils that formed in clayey lacustrine sediment more than 40 inches thick. These soils are on old lake plains.

This soil typically has a very dark gray silty clay surface layer and a gray silty clay subsurface layer. The subsoil is olive gray clay and silty clay, and the underlying material is light olive gray to dark gray silty clay and silty clay loam.

Permeability is moderately slow, and available water capacity is high. Water storage capacity is low, and water yield potential is high.

Use of this soil is limited mainly by wetness, high content of silt and clay, and frost action. Engineering construction activities are severely limited. Problems caused by frost action and high shrink-swell potential are common. Recreational uses of this soil are limited, and use of this soil for standard septic tank systems is severely limited. Precautions are necessary in timber management because of the high silt and clay content. This soil is erodible in cuts because of its texture and topographic position. Some areas, commonly ponded part of the growing season and therefore poorly suited to timber management, generally support grasses, sedges, and shrubs. Wildlife developments are feasible, and pothole developments and impoundments can be established. Where the soils are somewhat poorly drained, they respond to fertilization.

An overstory of black ash, trembling aspen, and white-cedar is typical. Shrubs are mainly alder, mountain maple, dogwood, and raspberry. Common forbs are threeflower bedstraw, woodland horsetail, bigleaf aster, grasses, and sedges.

Representative profile of Indus silty clay in a forested area in the SW1/4SW1/4SW1/4 sec. 32. R. 9 W., T. 64 N.:

O1—2 1/2 inches to 2; nondecomposed plant parts.
O2—2 inches to 0; dark reddish brown (5YR 3/2), partly decomposed plant parts; strongly acid.
A1—0 to 2 inches; very dark gray (10YR 3/1) silty clay; strong medium to coarse granular structure; firm; medium acid, clear irregular boundary.
A2—2 to 8 inches; gray (2.5Y 5/1) silty clay; common medium distinct mottles of dark yellowish brown (10YR 4/6); moderate medium angular blocky structure; firm; neutral; clear smooth boundary.
B21tg—8 to 12 inches; olive gray (5Y 4/2) clay; many fine prominent mottles of strong brown (7.5YR 5/8); strong very fine angular blocky structure; sticky; distinct complete clay films on ped faces and in pores; mildly alkaline; clear smooth boundary.
B22tg—12 to 22 inches; olive gray (5Y 5/2) clay; many medium prominent mottles of strong brown (7.5YR 5/8); strong fine angular blocky structure; sticky; distinct complete clay films on ped faces and in pores; mildly alkaline; gradual smooth boundary.
B3tg—22 to 43 inches; olive gray (5Y 5/2) silty clay; many medium prominent mottles of strong brown (7.5YR 5/8); strong medium prismatic structure parting readily to strong fine angular blocky; firm; distinct complete clay films on ped faces and in cavities; prominent complete clay films on prism faces; few calcium carbonate concretions as much as one-half inch in diameter; mildly alkaline; gradual smooth boundary.
Clg—43 to 51 inches; light olive gray (5Y 6/2) silty clay; many coarse prominent mottles of yellowish brown (10YR 5/6); moderate medium angular blocky structure; firm; mildly alkaline; clear smooth boundary.
C2—51 to 84 inches; 50 percent dark gray (5Y 4/1), 35 percent dark grayish brown (2.5Y 4/2) silty clay loam, varved; moderate medium to thick platy structure; firm; mildly alkaline.

Depth to free carbonates ranges from 12 to 30 inches. Depth to bedrock is typically 10 feet or more. The A horizon is loam, silt loam, silty clay loam, or silty clay. Reaction in the A horizon ranges from medium acid to neutral. The B horizon is silty clay loam, silty clay, or clay. Reaction in the B horizon is neutral or mildly alkaline. Reaction in the C horizon is mildly alkaline or moderately alkaline.

This soil has less clay and more silt than defined in the range for the Indus series. However, this difference does not appreciably affect its use and management.

The Indus soil is associated with Poorly drained loamy soils and Conic soils. It is more clayey than these soils.

ID—Indus silty clay (0 to 2 percent slopes). This soil is on terrain formerly occupied by glacial lakes. These areas are typically part of natural drainageways or are adjacent to lakes and streams.

Included with this soil in mapping were small areas of Mucky peats and better drained, more sloping clayey soils. Capability subclass IIIw.

Insula series

The Insula series consists of well drained, sloping to steep soils that formed in loamy material 8 to 20 inches thick over bedrock. These soils have complex slopes on bedrock-controlled terrain.

These soils typically have a thin organic surface layer and a gray gravelly sandy loam subsurface layer. The upper part of the subsoil is dark yellowish brown and dark brown gravelly sandy loam and has an accumulation of organic matter and iron and aluminum oxides. The lower part is brown and light olive brown gravelly sandy loam.

Permeability is moderately rapid, and available water capacity is very low. Shallowness to bedrock, coarse fragments, and slope cause low to moderate water storage capacity and high water yield potential.

Use of the soils is limited by shallowness to bedrock, droughtiness, and hilly terrain. Engineering uses are limited by depth to bedrock and slope. Recreational uses are limited. Use of standard septic tank systems is severely limited on these soils. Low productivity, windthrow hazard, and droughtiness limit timber production. Natural wildlife openings contain a variety of forbs and shrubs. Developed food plots respond satisfactorily to fertilization.

Vegetation common to these soils is an overstory of jack pine, trembling aspen, and balsam fir. Bushhoneysuckle, dwarf rose, and blueberry are typical shrubs. Common forbs are bigleaf aster, bunchberry, and twinflower.

Representative profile of Insula gravelly sandy loam, 2 to 18 percent slopes, in a forested area in the NE1/4NE1/4SW1/4 sec. 24, R. 9 W., T. 64 N.:

O1—1 1/2 inches to 1; undecomposed and decomposing plant remains.
O2—1 inch to 0; black (10YR 2/1), mostly decomposed plant material; strongly acid to slightly acid.
A2—0 to 3 inches; gray (10YR 6/1) gravelly sandy loam; weak fine and medium subangular blocky structure; friable; about 25 percent coarse fragments; medium acid; abrupt wavy boundary.
B21irh—3 to 6 inches; dark yellowish brown (10YR 3/4) gravelly sandy loam; weak medium subangular blocky structure; friable; about 25 percent coarse fragments; slightly acid; clear smooth boundary.
B22ir—6 to 9 inches; dark brown (10YR 3/3) gravelly sandy loam; weak fine subangular blocky structure and weak medium granular structure; friable; about 25 percent coarse fragments; slightly acid; clear smooth boundary.
B23—9 to 12 inches; brown (10YR 4/3) gravelly sandy loam; weak fine subangular blocky structure and weak fine granular structure; friable; about 25 percent coarse fragments; medium acid; clear smooth boundary.
B3—12 to 15 inches; light olive brown (2.5Y 5/4) gravelly sandy loam; weak fine and medium subangular blocky structure; friable; about 25 percent coarse fragments; medium acid; abrupt wavy boundary.
R—15 inches; granite.

Depth to bedrock, which is mostly of igneous and metamorphic origin, ranges from 8 to 20 inches. The content of coarse fragments ranges from 15 to 35 percent. Color in the A2 horizon is 10YR and 7.5YR in hue. Texture in the solum is fine sandy loam, sandy loam, coarse sandy loam, loam, and gravelly phases of these, or silt loam. Reaction in the solum is very strongly acid, strongly acid, medium acid, or slightly acid. Color in the B horizon is 10YR, 7.5YR, or, in the lower part, 2.5Y in hue.

Insula soils are associated with Conic and Quetico soils and are similar to Barto soils. Bedrock in Insula soils is at a depth of 8 to 20 inches; bedrock is below a depth of 20 inches in Conic soils and above a depth of 8 inches in Quetico soils. Insula soils have yellower hues in the B horizon than similar Barto soils.

ISC—Insula gravelly sandy loam, 2 to 18 percent slopes. This sloping soil is on ridgetops and upper side slopes and locally dominates the landscape. This soil has the profile described as representative for the Insula series.

Included with this soil in mapping were small areas of Barto soils. Also included were a few areas of Quetico soils on ridgetops and Poorly drained loamy soils in depressions.

Shallowness to bedrock and coarse fragment content cause low to moderate water storage capacity and high water yield potential. Capability subclass VIs.

ISC2—Insula gravelly sandy loam, 2 to 18 percent slopes, disturbed. This sloping soil is on ridgetops and upper side slopes and locally dominates the landscape. It has a profile similar to the one described as representative of the series, but the upper 3 to 8 inches has been removed as a result of cultural practices, which are activities associated with past land management.

Included with this soil in mapping were small areas of Barto soils. Also included were a few areas of Quetico soils on ridgetops and Poorly drained loamy soils in depressions.

Because of the loss of the upper 3 to 8 inches of soil material, water storage capacity is low. Water yield potential is high. The hazard of erosion in this soil is high because surface organic material has been lost. Capability subclass VIs.

ISE—Insula gravelly sandy loam, 18 to 35 percent slopes. This steep soil is on the lower parts of slopes near less sloping Insula and Conic soils, which are on the upper parts of slopes. This soil has a profile similar to the one described as representative of the series, but it is thinner.

Included with this soil in mapping were small areas of Barto soils. Areas of bedrock were included on ridgetops and along waterways and escarpments. Also included were some areas of stony soils.

Because the organic surface layer is thinner and slopes are steeper, surface runoff is higher and water storage capacity is low. Water yield potential is high. Capability subclass VIIs.

Mesaba series

The Mesaba series consists of well drained, sloping to steep soils that formed in loamy material 20 to 40 inches thick over bedrock. These soils are on irregular bedrock-controlled terrain.

These soils typically have a thin layer of undecomposed plant remains on the surface over a thin layer of mostly decomposed plant remains. The subsoil is gravelly sandy loam that is dark brown in the upper part and that grades to strong brown in the lower part. The upper part has an accumulation of organic matter and iron and aluminum oxides (fig. 3).

Permeability is moderately rapid, and available water capacity is low. These soils have low to moderate water storage capacity and high water yield potential.

These soils are limited mostly by moderate depth, seasonal droughtiness, and hilly terrain. Engineering uses are limited by depth to bedrock and slope. Recreational uses are limited. Use of standard septic tank systems is severely limited. Timber production is somewhat limited by restricted root development and windthrow hazard. Steeper soils having southern exposures are seasonally droughty. Managed wildlife openings are feasible. Developed food plots respond to fertilization.

Vegetation common on these soils is an overstory of trembling aspen, white birch, and jack pine. Shrubs are beaked hazel, hazel alder (speckled alder), and bushhoneysuckle. Common forbs are sarsaparilla, bunchberry, bigleaf aster, and rose twistedstalk.

Figure 3.—**The upper part of the well-developed B horizon in Mesaba soils is rich in organic matter, aluminum, and iron oxides.**

Representative profile of Mesaba gravelly sandy loam, 2 to 18 percent slopes, in a forested area in the SE1/4NW1/4SW1/4 sec. 9, R. 9 W., T. 62 N.:

O1—1 1/2 inches to 1; slightly decomposed plant remains.

O2—1 inch to 0; dark reddish brown (5YR 2/2) mostly decomposed plant remains; strongly acid.

B21hir—0 to 4 inches; dark brown (7.5YR 3/2) gravelly sandy loam; weak medium subangular blocky structure parting in places to weak fine granular; friable; about 25 percent coarse fragments; slightly acid; clear irregular boundary.

B22irh—4 to 9 inches; dark brown (7.5YR 4/4) gravelly sandy loam; weak fine subangular blocky structure; friable; about 25 percent coarse fragments; slightly acid; clear smooth boundary.

B31—9 to 16 inches; brown (7.5YR 5/4) gravelly sandy loam; weak medium subangular blocky and weak medium granular structure; friable; about 25 percent coarse fragments; medium acid; clear smooth boundary.

B32—16 to 28 inches; strong brown (7.5YR 5/6) gravelly sandy loam; weak fine granular structure; friable; about 20 percent coarse fragments; medium acid; abrupt smooth boundary.

R—28 inches; bedrock.

Depth to bedrock, which is mostly gabbro, ranges from 20 to 40 inches. The content of coarse fragments ranges from 15 to 40 percent (fig. 4). The coarse fragments are mostly of gravel size, but fragments of cobble and boulder size make up a significant part of the mass. Texture in the solum is sandy loam, fine sandy loam, coarse sandy loam, loam, and gravelly phases of these, or silt loam. Reaction in the solum ranges from very strongly acid to slightly acid.

Mesaba soils are commonly associated with Barto and Conic soils and with Poorly drained loamy soils. They are deeper over bedrock than Barto soils and do not have the fragipan that similar Conic soils have.

MEC—Mesaba gravelly sandy loam, 2 to 18 percent slopes. This sloping soil is typically on irregular ridgetops and upper side slopes. However, this soil dominates the landscape in many places adjacent to lowlands or major drainageways. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of Conic soils and Barto soils on ridgetops and side slopes. Also included were small areas of Poorly drained loamy soils in depressions and small drainageways. Bedrock outcrops are common along drainageways. In places in small depressions, the soil has a stony surface, is moderately well drained, and is deeper to bedrock.

Depth to bedrock is the major limitation to use. Capability subclass IVs.

MEC2—Mesaba gravelly sandy loam, 2 to 18 percent slopes, disturbed. This sloping soil is on irregular ridgetops and upper side slopes. It has a profile similar to the one described as representative of the series, but the upper three to eight inches has been removed as a result of cultural practices, which are activities associated with past land management.

Included with this soil in mapping were small areas of Conic soils and Barto soils on ridgetops. Also included were small areas of Poorly drained loamy soils in depressions. A few areas of steep soils were included because they are of such limited extent.

Because the upper 3 to 8 inches has been lost, this soil has lower water storage capacity and infiltration

Figure 4.—Coarse fragments, common in Mesaba soils, reduce the fertility level of the root zone.

rate and, consequently, a higher erosion hazard. Sediment from erosion contributes to nutrient levels in receiving waters. Establishment and maintenance of a vegetation cover should be a major management objective on this soil.

Use of the soil is limited by depth to bedrock. Capability subclass IVs.

MEE—Mesaba gravelly sandy loam, 18 to 35 percent slopes. This steep soil is on lower slope positions and is adjacent to poorly drained soils in many places. In places it is on the entire side slope. The profile of this soil is similar to the one described as representative of the series, but it is thinner and surface stones are more common.

Included with this soil in mapping were small areas of Conic and Barto soils and Well drained loamy and gravelly soils. Bedrock outcrops on steplike side slopes were included along drainageways. Also included were a few areas of stony soils.

This soil is limited mainly by steep slopes and seasonal droughtiness. Capability subclass VIIe.

Mucky peats

MP—Mucky peats (0 to 2 percent slopes). These very poorly drained soils are in drainageways, lake basins, and bogs adjacent to lakes. Mucky peats are typically organic soil materials extending to depths of 51 inches and more. Mineral and limnic materials are below the organic materials.

These soils are typically dark brown to dark reddish brown, moderately decomposed, very strongly acid to neutral organic material. The upper 12 inches is poorly decomposed and moderately decomposed organic materials. Subsurface layers are moderately decomposed and, in places, well decomposed organic material.

Mucky peats are commonly associated with Waskish soils (slightly decomposed organic material), Seelyeville soils (highly decomposed organic material), and Poorly drained loamy soils.

Permeability is moderately rapid, and available water capacity is very high. Water storage capacity and water yield potential are high. The seasonal high water table is at a depth of less than 2 feet. These soils can retain or detain surface and subsurface water and nutrients and sediment washed from adjacent uplands.

These soils are limited by the high water table and the unstable organic soil material. All major engineering construction activities are severely limited. Proper design and installation of road drainage structures and tiles are necessary to minimize flooding and the problems that accompany flooding. Major recreational developments are not feasible. These soils have severe limitations for standard septic tank systems. Potential for black spruce and white-cedar production is poor. Limited root growth and severe windthrow hazard are caused by the high water table. Potential for wildlife cover and food is good, and waterfowl pothole developments are feasible.

Vegetation common to this unit is an overstory of black spruce, tamarack, and white-cedar. Shrubs are mainly dwarf birch, hazel alder (speckled alder), leatherleaf, and labradortea. Sedges, sphagnum, and running clubmoss are common. Capability subclass VIIw.

Newfound series

The Newfound series consists of well drained, sloping to steep soils that formed in loamy glacial till more than 40 inches thick. These soils are on moraines.

These soils typically have a thin surface layer of partly decomposed plant remains over a subsurface layer of grayish brown gravelly sandy loam. The subsoil is yellowish brown to dark brown gravelly sandy loam that has an accumulation of organic matter and iron and aluminum oxides. A fragipan is at a depth of 16 inches. The underlying material is yellowish brown gravelly sandy loam (fig. 5).

Permeability is slow, and available water capacity is moderate. Shallow depth to the fragipan, coarse fragments, and slope cause moderate water storage capacity and water yield potential.

Use of the soils is limited mainly by restricted in-

Figure 5.—**Newfound soils have a fragipan that restricts root development and water movement. The top of the fragipan is immediately below the knife handle and extends below the bottom of the pit.**

ternal drainage, steep slopes, and shallowness to the fragipan. Engineering uses are moderately limited. The soils are moderately limited for recreational developments, and use of the soils for standard septic tank systems is severely limited. Seasonal droughtiness, restricted root development, and windthrow hazard moderately limit timber production. These soils are better suited to pulpwood production than to sawtimber production. Wildlife developments are feasible because adjacent drainageways and poorly drained soils offer cover and edge effect. The soils respond to fertilization in managed food plots.

Vegetation common to this soil is an overstory of white birch and trembling aspen. Shrubs are mainly beaked hazel, thimbleberry, and mountain maple. Common forbs are bigleaf aster, sarsaparilla, rose twistedstalk, and yellow clintonia.

Representative profile of Newfound gravelly sandy loam, 2 to 18 percent slopes, in a forested area in the SW¼SE¼NE¼ sec. 6, R. 9 W., T. 63 N.:

O1—2¼ inches to 1½; slightly decomposed plant remains.
O2—1½ inches to 0; black (5YR 2/1), mostly decomposed plant remains; medium acid.
A2—0 to 5 inches; grayish brown (10YR 5/2) gravelly sandy loam; weak medium subangular blocky fragments; very strongly acid; clear wavy boundary.
B21irh—5 to 11 inches; yellowish brown (10YR 5/4) gravelly sandy loam; weak medium subangular blocky structure parting in places to weak medium granular; friable; about 35 percent coarser fragments; many thin silty coatings on upper surfaces of coarse fragments; strongly acid; clear wavy boundary.
B22ir—11 to 16 inches; dark brown (10YR 4/3) gravelly sandy loam; weak fine subangular structure and weak medium granular structure; friable; about 25 percent coarse fragments; strongly acid; gradual wavy boundary.
Bx1—16 to 26 inches; light yellowish brown (10YR 6/4) gravelly sandy loam; moderate medium platy structure breaking to moderate medium subangular blocky fragments; firm; strongly cemented; about 25 percent coarse fragments; strongly acid; clear wavy boundary.
Bx2—26 to 32 inches; pale brown (10YR 6/3) gravelly sandy loam; massive breaking to moderate medium subangular blocky fragments; firm; strongly cemented; about 25 percent coarse fragments; medium acid; clear wavy boundary.
Clx—32 to 37 inches; yellowish brown (10YR 5/4) gravelly sandy loam; massive breaking to weak medium subangular fragments; firm; strongly cemented; about 25 percent coarse fragments; medium acid; gradual wavy boundary.
C2x—37 to 50 inches; yellowish brown (10YR 5/6) gravelly sandy loam; massive breaking to weak medium subangular blocky fragments; extremely firm; about 40 percent coarse fragments; medium acid.

Thickness of the solum ranges from 18 to 40 inches. Depth to bedrock is commonly more than 5 feet. Depth to the upper boundary of the fragipan is 14 to 28 inches. Content of coarse fragments in the solum ranges from 15 to 35 percent, by volume. Texture in the solum is sandy loam, coarse sandy loam, fine sandy loam, loam, and gravelly phases of these, and silt loam. Reaction in the solum ranges from very strongly acid to medium acid.

Newfound soils are associated with Conic and Mesaba soils. They are deeper over bedrock than those soils. They have a fragipan, and Mesaba soils do not.

NFC—Newfound gravelly sandy loam, 2 to 18 percent slopes. This sloping soil is on side slopes and ridgetops. Slopes are mostly convex. This soil has the profile described as representative of the series.

Included with this soil in mapping were small areas of Conic soils and Well drained loamy and gravelly soils.

These soils are limited mainly by the depth to the fragipan and the coarse fragment content. Capability subclass IVs.

NFE—Newfound gravelly sandy loam, 18 to 25 percent slopes. This steep soil typically is on middle and lower side slopes. It has a profile similar to the one described as representative for the series but is thinner.

Included with this soil in mapping were small areas of Well drained loamy and gravelly soils.

These soils are limited mainly by steep slopes, depth to fragipan, and coarse fragment content. Capability subclass VIe.

Poorly drained loamy soils

PD—Poorly drained loamy soils. This unit consists of poorly drained stony soils that formed in till more than 40 inches thick. The soils are nearly level on ground moraines and in upland depressions, natural drainageways, and bog perimeters.

This soil typically has a surface organic layer and a black or dark grayish brown subsurface layer. The subsoil and underlying material are dominantly mottled dark grayish brown to yellowish brown sandy loam. Bedrock is at a depth of more than 40 inches.

The surface organic layer is typically mucky peat that ranges from 4 to 18 inches in thickness. The subsoil and underlying material have a broad range of colors, from very dark gray to light olive brown, and most are mottled with reddish colors. The dominant texture is sandy loam, but texture is loamy sand, sandy clay loam, and loam in places. This soil is typically medium acid or slightly acid but ranges from very strongly acid to neutral. Coarse fragment content in the profile ranges from 5 to 15 percent, by volume. Five to 40 percent of the surface is covered with stones.

The principal associated soils are Barto, Conic, Insula, and Mesaba soils. These soils are well drained and less than 40 inches deep over bedrock.

Included with this soil in mapping were small areas of Mucky peats and Rubble land.

The seasonal high water table is at a depth of 0 to 4 feet. Permeability is moderate to moderately slow, and available water capacity is moderate. These soils sometimes retain or detain surface and subsurface water movement. Water storage capacity and water yield potential are high.

These soils are limited mostly by the high water table and the stony surface. Engineering use is limited by the water table. Seasonal runoff should be considered in the design and construction of engineering structures. All major recreation activities are severely limited. Sewage disposal systems are severely limited. Low productivity, windthrow hazard, and frost action limit timber production. There is a variety of wildlife food plants because of extensive edge effect along borders of these soils and because of accumulated nutrients in the soil. Waterfowl ponds can be developed on these soils.

Common vegetation on these soils is an overstory of trembling aspen and balsam fir. Shrubs are mainly green alder, redosier dogwood, and mountain maple. Common forbs are yellow clintonia, bunchberry, and threeflower bedstraw. Capability subclass VIIs.

Quetico series

The Quetico series consists of somewhat excessively drained, sloping to steep soils that formed in loamy material 4 to 8 inches thick over bedrock. These soils are on ridgetops in bedrock-controlled terrain.

These soils typically have a thin surface layer of undecomposed and partly decomposed plant remains over a subsoil that is dark brown loam in the upper part and strong brown loam in the lower part. This layer has an accumulation of organic matter and iron aluminum oxides (fig. 6).

Permeability is moderate, and available water capacity is very low. Shallowness to bedrock and sloping topography cause low water storage capacity and high water yield potential.

Vegetation common to this soil is an overstory of jack pine. Shrubs are mainly beaked hazel, redosier dogwood, and blueberry. Common forbs are bigleaf aster, sarsaparilla, bunchberry, and yellow clintonia.

Representative profile of Quetico loam in an area of Quetico-Rock outcrop complex, 5 to 18 percent slopes, in a forested area in the NE½SE¼NW¼ sec. 24, R. 7 W., T. 65 N.:

O1—1 inch to ½; undecomposed plant remains.

O2—½ inch to 0; black (5YR 2/1) mostly decomposed plant remains; very strongly acid.

B21hir—0 to 1½ inches; dark brown (7.5YR 3/4) loam; weak fine subangular blocky structure; friable; about 5 percent coarse fragments; very strongly acid; abrupt smooth boundary.

B22hir—1½ to 5inches; strong brown (7.5YR 3/6) loam; weak fine subangular blocky structure; friable; about 5 percent coarse fragments; very strongly acid; abrupt smooth boundary.

R—5 inches; granite bedrock.

Thickness of the solum coincides with depth to bedrock and ranges from 4 to 8 inches. The content of coarse fragments, mostly gravel and cobbles, ranges from 3 to 15 percent. The texture of the solum is sandy loam, loam, and silt loam. Reaction is very strongly acid or strongly acid.

QRC—Quetico-Rock outcrop complex, 5 to 18 per-

Figure 6.—An area of Quetico-Rock outcrop complex that can be developed for trails. Natural openings are common.

cent slopes. This complex of sloping soils is in undulating to hilly terrain. It is on broad ridges and in areas bordering drainageways and lakeshores. The Quetico soil in this complex has the profile described as representative of the Quetico series. Approximately 65 to 80 percent of this complex is Quetico loam, and 20 to 35 percent is Rock outcrop.

Included with this soil in mapping were some small areas of Barto and Insula soils.

Runoff is medium to rapid. The hazard of erosion is severe to moderate. Depth to bedrock limits most uses. Capability subclass VIIs.

QRE—Quetico-Rock outcrop complex, 18 to 35 percent slopes. This complex of steep soils is on narrow ridges and lower slopes bordering drainageways and bodies of water. Approximately 65 to 80 percent of this complex is Quetico loam, and 20 to 35 percent is Rock outcrop. Rock outcrop is associated with escarpments in many areas.

Included with this soil in mapping were a few small areas of Barto and Insula soils.

Runoff is rapid. The hazard of erosion is severe. Use of these soils is severely limited by depths to bedrock and steep slopes. Capability subclass VIIs.

Rubble land

RL—Rubble land (2 to 25 percent slopes). This land type consists of cobbly and stony areas with soil material partly filling the interstices (fig. 7). The soil material is typically dark reddish brown to dark brown, medium acid to neutral coarse sandy loam to clay loam. It is well drained to poorly drained. It is gently sloping to steep and is adjacent to lakes, in drainageways, and at the bases of slopes.

Content of surface and subsurface stones ranges from 70 to almost 100 percent. Fragments are mostly of cobble and stone size and are related to the local bedrock.

Rubble land is mainly near Barto and Mesaba soils. These soils are less than 40 inches deep over bedrock and do not have concentrations of boulders.

Areas of Rubble land have little practical use. The sparse vegetative cover consists of shrubs and stands of low-quality deciduous and coniferous trees. Common

***Figure 7.*—Area of Rubble land, which is common in the southeastern corner of the Kawishiwi Area. Rubble land has limited vegetative cover.**

overstory trees are white birch, trembling aspen, spruce, and balsam fir. Shrubs common on this soil are alder, blueberry, and hazel. Mosses, bluebead, and bigleaf aster are common forbs. Capability subclass VIIIs.

Seelyeville series

The Seelyeville series consists of very poorly drained, nearly level soils that formed in organic soil material more than 51 inches thick. These soils are in drainageways, lake basins, and depressions.

These soils are very dark brown to dark reddish brown, highly decomposed organic soil material. They range from very strongly acid to neutral, and the organic material is primarily herbaceous fibers.

The water table is at a depth of less than 2 feet. Permeability is moderately rapid, and available water capacity is very high. These soils retain or detain surface and subsurface water and associated nutrients.

Use of the soils is limited by the high water table and the instability of the organic soil material. All major engineering construction activities are severely limited. Properly designed road drainage structures are needed to prevent damming and the problems that accompany damming. All major recreational developments, including standard septic tank systems, are severely limited. These soils are suited to properly designed nature trails. Timber production potential is limited. The high water table restricts root growth and therefore increases the hazard of windthrow. Waterfowl ponds can be developed. Edge effect provides a variety of vegetation.

Overstory vegetation includes white-cedar, tamarack, black spruce, and black ash. The shrub cover consists mainly of green alder, dwarf birch, and willow. Common forbs, grasses, and related species are wild iris, bog-cotton, cattail, and sedges.

Representative profile of Seelyeville mucky peat in a forested area in the SE¼SW¼SW¼ sec. 10, R. 5 W., T. 63 N.:

Oel—0 to 12 inches; very dark brown (7.5YR 2/2) on broken faces, dark reddish brown (5YR 3/2) rubbed hemic material; about 50 percent fiber, 40 percent rubbed; about 70 percent herbaceous fibers, 30 percent woody fiber; medium acid.

Oal—12 to 18 inches; very dark brown (7.5YR 2/2), dark brown (7.5YR 3/2) pressed, very dark brown (10YR 2/2) rubbed sapric material; about 10 percent fiber, 2 percent rubbed; 90 percent herbaceous fiber, 10 percent woody fiber; slightly acid.

Oa2—18 to 39 inches; dark reddish brown (5YR 3/2) dark reddish brown (5YR 2/2) pressed and rubbed sapric material; about 25 percent fiber; 12 percent rubbed; about 90 percent herbaceous fiber, 10 percent woody fiber; slightly acid.

Oa3—39 to 66 inches; dark brown (7.5YR 4/4) dark brown (7.5YR 3/2) pressed, very dark grayish brown (10YR 3/2) rubbed sapric material; about 30 percent fiber, 15 percent rubbed; primarily herbaceous fiber; neutral.

The organic soil material is very dark brown, dark brown, dark reddish brown, and black. Reaction ranges from strongly acid to neutral. Some hemic material is in the lower part of the profile in places.

Seelyeville soils are commonly associated with Mucky peats, Poorly drained loamy soils, and Quetico and Barto soils. Seelyeville soils consist of highly decomposed organic material; Mucky peats are only moderately decomposed, and the other soils are mineral soils.

SE—Seelyeville muck (0 to 2 percent slopes). This nearly level, very poorly drained soil is typically in drainageways, old lake basins, and depressions. Areas are mostly less than 50 acres in size but range from 5 to about 100 acres (fig. 8).

Included with this soil in mapping were some areas of Mucky peats and Waskish soils. Capability subclass IVw.

Waskish series

The Waskish series consists of very poorly drained, nearly level soils that formed in slightly decomposed organic material more than 63 inches thick. These soils are in drainageways, lake basins, and depressions.

Typically these soils are dark reddish brown to dark yellowish brown, poorly decomposed organic soil material. Remains of sphagnum mosses dominate the poorly decomposed material. Reaction is extremely acid throughout.

The water table is at a depth of less than 2 feet. Permeability is rapid, and available water capacity is very high. These soils retain or detain water, nutrients, and sediment from adjacent uplands.

Use of the soils is limited by extreme acidity, the high water table, depth of the organic soil material, and the instability of the organic soil material. All major engineering construction activities, all major recreational developments, and standard septic tank systems are severely limited. Potential for timber production is very limited. The high water table restricts root growth and therefore increases the hazard of windthrow. Productivity potential is low. Potential for

Figure 8.—**Seelyeville soils (background) and other organic soils (foreground) make up about 10 percent of the Kawishiwi Area. These soils are typically in old lake basins and drainageways.**

wildlife shelter and waterfowl ponds is fair, but potential for wildlife food is low.

Stunted black spruce is the common overstory. Shrubs consist mainly of cottongrass, labradortea, leatherleaf, and pitcher plant. Ground cover consists of small cranberry, sedges, and sphagnum and hypnum mosses.

Profile of Waskish peat in a forested area in the SE¼NE¼SE¼ sec. 7, R. 9 W., T. 64 N.:

Oi1—0 to 20 inches; dark reddish brown (5YR 3/3), strong brown (7.5YR 3/6) pressed, dark brown (7.5YR 3/4) rubbed fibric material about 85 percent fiber, 75 percent rubbed; sphagnum fibers; hemic band 1½ inches thick at a depth of 14 inches; extremely acid.

Oi2—20 to 26 inches; dark reddish brown (5YR 2/4), very dark brown (7.5YR 2/2) pressed and rubbed fibric material; about 80 percent fiber, 70 percent rubbed; about 75 percent sphagnum moss fiber, 25 percent herbaceous fiber; charcoal bands one-fourth inch thick at depths of 21½ and 26½ inches; extremely acid.

Oi3—26 to 40 inches; dark brown (7.5YR 3/2), dark brown (7.5YR 4/4) pressed and rubbed fibric material; about 85 percent fiber; 80 percent rubbed; 75 percent sphagnum moss fiber and 25 percent herbaceous fiber; coarse woody fiber layer 1½ inches thick at a depth of 31 inches; extemely acid.

Oi4—40 to 47 inches; dark reddish brown (5YR 3/3), dark reddish brown (5YR 3/4) pressed, dark brown (7.5YR 4/4) rubbed fibric material; about 85 percent fiber, 50 percent rubbed; primarily sphagnum moss fiber; extremely acid.

Oi5—47 to 54 inches; dark reddish brown (5YR 2/4) on broken face, pressed and rubbed fibric material; about 85 percent fiber, 55 percent rubbed; primarily sphagnum moss fiber; extremely acid.

Oi6—54 to 64 inches; dark reddish brown (5YR 3/3) on broken face, prèssed and rubbed fibric material; about 80 percent fiber, 55 percent rubbed; primarily sphagnum moss fiber; woody fiber layer 1 inch thick at a depth of 60 inches; extremely acid.

Oi7—64 to 86 inches; dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6) pressed and rubbed fibric material; about 90 percent fiber, 85 percent rubbed; 50 percent sphagnum moss fiber, 40 percent herbaceous fiber, and 10 percent woody material; extremely acid.

The organic soil materials extend to a depth of 80 to 150 inches. Mineral or limnic materials are below the organic material. The upper 26 inches is mostly sphagnum moss fiber; unrubbed fiber content ranges from 80 to 100 percent. Thin layers (¼ inch to 3½ inches thick) of hemic and sapric materials are common. Between depths of 26 and 48 inches is mostly sphagnum moss fiber and as much as 25 percent herbaceous fiber.

Waskish soils are associated with Mucky peats but are less decomposed.

WA—Waskish peat (0 to 2 percent slopes). This nearly level, very poorly drained soil is typically in bogs of more than 250 acres in size with open water.

Included with this soil in mapping were small areas of Mucky peats, commonly on the perimeter of the Waskish soil. Capability subclass VIIw.

Well drained loamy and gravelly soils

WD—Well drained loamy and gravelly soils (6 to 25 percent slopes). This unit consists of loamy, sandy, and gravelly material that formed in deep deposits of glacial till and glacial outwash. These sloping to steep soils are on moraines and have single, uniform, convex slopes.

Typically these soils have a thin organic surface layer underlain by a gray subsurface layer. The subsoil and underlying material are dominantly brown to yellowish brown or pale brown. In some areas accumulations of organic matter, iron, and aluminum oxide are in the subsoil. The upper part of the profile is dominantly sandy loam but is loam and gravelly sandy loam in places. The lower part ranges from sand and gravelly sand to sandy loam. Content of coarse fragments ranges from 5 to 90 percent. Gravel and cobble content increases with depth. These soils are very strongly acid to medium acid.

This soil is associated mainly with Conic and Insula soils, which are less than 40 inches deep over bedrock.

Included with this soil in mapping were small areas of Conic and Insula soils on upper slopes and some areas of Newfound soils.

Permeability is moderate to rapid, and available water capacity is low to high. Coarse fragment content and particle size distribution cause low water storage capacity and high to moderate water yield potential.

The soils are limited mainly by the thickness of the loamy mantle, droughtiness, low inherent fertility, steep slopes, and erosion hazard. There are slight to moderate limitations for most engineering uses. This soil is a good source of borrow material. Cuts and fills need topsoil and fertilizer so vegetation that stabilizes the soil can grow. Intensive recreational developments may require a soil conditioner, fertilizer, and irrigation if a durable ground cover is to be established and maintained. Slope is the main limitation for standard septic tank systems. Low natural fertility and droughtiness could limit reforestation and timber production. Site preparation techniques for any development should ensure minimum disturbance to the surface soil. Developed wildlife food plots on deep sandy loams respond to fertilization.

These soils are forested. Common vegetation includes an overstory of white birch, trembling aspen, and balsam fir. Shrub cover consists largely of beaked hazel, bracken fern, bushhoneysuckle, and mountain maple. Common forbs are sarsaparilla, yellow clintonia, and starflower. Capability subclass VIs.

III. Soil Resource Interpretations

The resource interpretations presented in this section are based on current guidelines and on field data. The text deals with general soil information and is meant for general planning. The tables give information about each soil and can be used to support detailed planning.

This section can be used to help determine the potential of a given area for a specific use. Special efforts must be made to prevent overuse of the soil. Overuse often results in loss of fertility, reduced available water capacity, soil erosion, and vegetative cover.

The interpretations presented in this section are designed to assist area and unit resource managers. For the area manager, the general soil map and augmenting data are of primary interest. However, the unit manager needs more intensified maps and related data.

An area resource manager can use the information in this section when preparing plans to be coordinated with other resource management groups. For example, a resource manager's plan might include the total acreage suitable for the production of pulpwood or sawtimber or the total acreage suitable for recreation. Also included in such a plan might be gross figures on water yield and statements regarding areawide wildlife management proposals. Such a plan can provide direction for unit managers.

The unit manager could readily use the more detailed information in this survey for on-the-ground action plans. This intensified soil resource information generally provides guidance for planning in areas as small as about 20 acres. A unit manager could use this soil information for site preparation and reforestation. Detailed water yield could be computed. Areas could be selected and prescriptions prepared for wildlife projects. Areas having prime recreation potential could also be located. In the preparation of some plans, consultation with a soil scientist may be necessary for interpretations and onsite investigations.

Soil interpretations in this section are presented by major resource headings and are based on the mapping unit. Interpretations are presented in text and tables. These interpretations are valid for several decades and are customarily extended by periodic updating, which reflects changes in technology.

Soil Associations

The Kawishiwi Area has been separated into four general soil associations that are pertinent to resource management. The associations are grouped on the basis of similarities among soils.

1. Conic-Insula-Indus association

Shallow to moderately deep soils that formed in loamy glacial till over bedrock, and deep clayey soils that formed in lacustrine material

Vermilion Granite prevails in the western one-third of the area of this association, and Knife Lake Group (graywacke, argillite, phyllite, conglomerate, and volcanic rocks) and Vermilion Granite prevail in the northeastern two-thirds. A major fault along the Canadian border extends southwestward through Birch, Sucker, Newfound, and Moose Lakes. Glacial till dominates the steep upland areas, and lacustrine deposits believed to be related to Glacial Lake Agassiz occupy most gently sloping areas.

Conic and Insula soils are well drained, and they are the steeper soils of the uplands. Conic soils are gravelly sandy loam 20 to 40 inches deep over bedrock, and they have a well developed fragipan at a depth of 14 to 18 inches. Insula soils are gravelly sandy loam 8 to 20 inches deep over bedrock. Indus soils formed in lacustrine deposits in old lakebeds. They are somewhat poorly drained and poorly drained. They are silty clay and clay more than 40 inches deep. Minor soils in this association include Mucky peats, mainly in a large bog of 1,000 acres, and Waskish and Seelyeville soils in small bogs of 50 acres or less near Indus soils.

Most uses of the soils in this association are moderately to severely limited because of shallowness to bedrock, poor drainage, and steep slopes.

Ridgetops dominated by Insula soils, which are less than 20 inches deep over bedrock, commonly support stands of jack pine that have a low site index. Ridgetops dominated by Conic soils, which are more than 20 inches deep over bedrock, typically support mixed stands dominated by trembling aspen or white birch that has an understory of white spruce and balsam fir. Indus soils support stands of trembling aspen, black ash, and white-cedar.

2. Conic-Insula-Well drained loamy and gravelly soils association

Shallow to moderately deep soils that formed in loamy glacial till over bedrock, and deep loamy to gravelly soils that formed in till and outwash

Knife Lake Group and Ely Greenstone (basaltic rock) dominate this association. The soils in the association formed mainly in glacial till. They vary in thickness from less than 20 inches to more than 10 feet. The shallower soils are on bedrock-controlled sites. They commonly have bedrock outcrops and complex concave slopes. The deeper soils are on moraines. They typically do not have bedrock outcrops and they have simple convex slopes and are less steep than the shallower soils. Lacustrine deposits and organic soils occupy an insignificant percentage of the total area.

The well drained Conic soils are gravelly sandy loam 20 to 40 inches deep over bedrock. A well developed fragipan is at a depth of 14 to 18 inches. The well drained Insula soils are gravelly sandy loam 8 to 20 inches deep over bedrock. Well drained loamy and gravelly soils are sandy loam over sand, gravelly loamy sand, gravelly sandy loam, and sands and gravels more than 40 inches, and commonly more than 10 feet, thick. Cobbles and boulders are characteristic in the substratum.

This association has good potential as a source of sand and gravel and as building sites. Limitations to use are the result of shallowness over bedrock, seasonal droughtiness, and steep slopes.

Jack pine that has a low site index is common on Conic and Insula soils; however, jack pine that has good site index grows on Well drained loamy and gravelly soils. White birch and trembling aspen are common on Well drained loamy and gravelly soils.

3. Conic-Insula-Quetico association

Very shallow to moderately deep soils that formed in loamy glacial till over bedrock

Knife Lake Group and granite dominate the northern one-half of the association, and Duluth Gabbro prevails in the southern one-half. A till mantle covers the area. Organic soils and lacustrine deposits are very uncommon, occupying sites of less than 10 acres. This area has the greatest local relief in the entire survey area. Variations of 75 to 200 feet within one-eighth to one-fourth mile are common. Slopes are complex, concave, and irregular, giving the area a rugged quality.

The well drained Conic soils are gravelly sandy loam 20 to 40 inches deep over bedrock. A well developed fragipan is at a depth of 14 to 18 inches. The well drained Insula soils are gravelly sandy loam 8 to 20 inches deep over bedrock. The somewhat excessively drained Quetico soils are less than 8 inches of till over bedrock.

Uses of the soils in this association are severely limited by shallowness over bedrock, droughtiness, and steep slopes.

Natural stands of red pine and white pine are more common in this association than in the remainder of the survey area. Jack pines ranging in age from 75 to 115 years grow in stands of aspen. Pine trees grow mostly on the upper parts of slopes, deciduous trees grow mostly on the lower parts of slopes, and lowland conifers grow mostly in areas of poorly drained soils. These relationships vary throughout the area; they are distinct in some sites and subtle in others.

4. Mesaba-Barto-Mucky peats association

Shallow to moderately deep soils that formed in loamy glacial till over bedrock, and deep mucky peat soils that formed in organic material

Duluth Gabbro prevails throughout this association. The terrain is less steep than in the remainder of the survey area. Local relief is also much less, and some areas are actually flat. Bedrock outcrops are less common in this association than in the remainder of the survey area. A mantle of till dominates the association. It ranges in thickness from less than 20 inches to more than 40 inches. On scattered sites, the soils are more than 10 feet thick. These sites range from less than 1 acre to 20 acres in size. Slopes are complex and concave. Lacustrine deposits are extremely uncommon; they are only in the northwest one-fourth of the association.

The well drained Mesaba soils are gravelly sandy loam 20 to 40 inches deep over bedrock. The well drained Barto soils are gravelly sandy loam 8 to 20 inches deep over bedrock. Mucky peats are poorly drained. They are moderately decomposed plant material more than 60 inches thick. These organic soils are patterned uniformly throughout the association near drainageways, streams, and lakes.

Vegetation relationships are less distinct in this association than in the others. The general relationship between upland sites and lowlands and bogs is applicable, but ridgetops tend to be wider and flatter and perhaps less droughty. Because of this, trembling aspen and jack pine stands dominate the landscape but not particular landscape positions.

Engineering

Soil engineering data presented in this section are based on detailed field investigations, laboratory analyses, and estimates based on data for similar soils (*6*). The interpretations in table 3 are designed to assist the engineer in:

1. Selecting road locations that will minimize development and maintenance costs.
2. Locating borrow sources for gravel, clay, and topsoil.
3. Determining location and size of drainage structures.
4. Minimizing ponding of surface water at road crossings in natural drainageways and along fill areas.
5. Stabilizing cut and fill slopes.
6. Selecting locations for water impoundments.
7. Maximizing the perpetuation of esthetic landscape features.
8. Locating potential problem areas.

Basically the mineral soils in the survey area are not well suited to most engineering activities. Depth to consolidated bedrock is less than four feet in most places. Typically the soils have a relatively high silt content and a low clay content. Natural drainageways are commonly occupied by organic soils—peat and muck and clayey soils. A broken irregular and sloping landscape dominates the Area. The low water storage capacity in the soils causes high water levels in drainageways, streams, and lakes during the spring melt. This is particularly true of the clayey Indus soils and the organic soils that are bounded by previous upland soils that are moderately shallow over bedrock.

With the use of the soil map for identification, the engineering interpretations in this section can be used for many purposes. It should be emphasized, however, that these interpretations do not eliminate the need for sampling and testing at the sites of specific engineering works involving heavy loads and where the excavations are deeper than the depths of the layers here reported. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Following are explanations of the columns in table 3.

USDA texture takes into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly coarse sandy loam."

Depth to bedrock is the distance from the surface of the soil to the upper surface of the rock layer.

Natural drainage refers to the conditions of frequency and duration of periods of saturation or partial saturation in unaltered soil.

Depth to seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

The Unified system (*3*) is used by SCS engineers, the Department of Defense, and others. In it, soils are classified according to particle size distribution, plasticity, liquid limit, and organic matter content. There are four classes of coarse-grained soils, identified as GW, GP, SW, and SP; four classes of fine-grained soils, identified as ML, CL, MH, and CH; four combinations of coarse-grained and fine-grained soils, identified as GC, GM, SC, and SM; and three organic soils, identified as OL, OH, and Pt. Soils on the borderline between two classes are designated by symbols for both classes, for example, CL–ML.

The AASHTO system (*2*) is the system of the

TABLE 3.—*Soil properties*

[Symbol > means more than;

Soil series and map symbols	USDA texture	Depth to bedrock	Natural drainage	Depth to high water table
		In		*Ft*
Barto: BAC, BAC2, BAE	Gravelly coarse sandy loam	8–20	Well drained	>6
Conic: COC, COE	Gravelly sandy loam	20–40	Well drained	>6
Indus: ID	Silty clay to clay	>40	Somewhat poorly drained to poorly drained.	<4
Insula: ISC, ISC2, ISE	Gravelly sandy loam	8–20	Well drained	>6
Mesaba: MEC, MEC2, MEE	Gravelly sandy loam	20–40	Well drained	>6
Mucky peats: MP	Mucky peat (hemic)	>51	Very poorly drained	<2
Newfound: NFC, NFE	Gravelly sandy loam	>40	Well drained	>5
Poorly drained loamy soils: PD	Varied	>40	Poorly drained	<3
Quetico: QRC, QRE	Loam	4–8	Somewhat excessively drained.	>6
Rubble land: RL		>40	Well drained to poorly drained.	Variable
Seelyeville: SE	Muck (sapric)	>51	Very poorly drained	<2
Waskish: WA	Peat (fibric)	>63	Very poorly drained	<2
Well drained loamy and gravelly soils: WD.	Varied	>40	Well drained	>5

[1] Permeability in Conic soils above a depth of 15 inches and below a depth of 26 inches is 2.0 to 6.0 inches per hour.

American Association of State Highway and Transportation Officials. It is used to classify soils according to the properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups, designated A–1 through A–7 on the basis of grain size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and that are the poorest soils for subgrade.

Infiltration is the downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Permeability is the quality of a soil that enables it to transmit water or air. It is estimated on the basis of soil characteristics observed in the field, particularly structure and texture. The estimates in table 3 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Reaction is the degree of acidity or alkalinity of a soil, as expressed in pH values. The pH value and terms used to describe soil reaction are described in the Glossary.

Frost action potential is the likelihood of upward or lateral expansion (frost heave) of soil because of the formation of segregated ice lenses and the subsequent loss of strength and collapse on thawing.

Shrink-swell potential is the relative change to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes damage to building foundations, roads, and other structures.

Recreation

The soils in the Kawishiwi Area can support diverse recreational uses. Deep, well drained, medium textured soils are suitable for the intensive development necessary for campgrounds, picnic areas, play areas, and similar developments that support concentrated use. Shallow soils, poorly drained organic soils, and somewhat poorly drained and poorly drained clayey soils are limited in their potential for recreational use.

Shallow soils subject to compaction and with sloping to hilly terrain are best suited to dispersed uses such as hiking and hunting. Deep, well drained soils are suitable for campgrounds, visitor centers, and similar uses.

Water impoundments are feasible in the somewhat *significant to engineering*

symbol < means less than]

Classification		Infiltration	Permeability	Reaction	Frost action potential	Shrink-swell potential
Unified	AASHTO					
		In per hr	*In per hr*	*pH*		
SM, GM	A–4, A–2	0.15–0.30	2.0 – 6.0	4.5–6.0	Moderate	Low.
SM, GM	A–4, A–2	0.15–0.30	[1] 0.06 – 0.2	4.5–6.0	Moderate	Low.
CH	A–7	0.05–0.15	0.2 – 0.6	5.6–8.4	High	High.
SM, GM	A–4, A–2	0.15–0.30	2.0 – 6.0	5.1–6.5	Moderate	Low.
SM, GM	A–4, A–2	0.15–0.30	2.0 – 6.0	4.5–6.5	Moderate	Low.
Pt	—	—	2.0 – 6.0	4.5–7.3	—	
SM, GM	A–4, A–2	0.15–0.30	[2] 0.06 – 0.2	4.5–6.0	Moderate	Low.
SM–ML	A–4 to A–6	0.05–0.30	0.2 – 2.0	4.5–7.3	Moderate	Moderate.
CL, ML	A–4	—	0.6 – 2.0	4.5–5.5	Low	Low.
—	—	—	—	—	Low	Low.
Pt	—	—	2.0 – 6.0	5.1–7.3	—	
Pt	—	—	6.0 –20.0	4.0–4.3	—	
GW, GP, SM	A–1, A–2, A–3, A–4	0.15–0.30	0.6 –20.0	4.7–5.8	Low to moderate	Low.

[2] Permeability in Newfound soils above a depth of 16 inches is 2.0 to 6.0 inches per hour.

poorly drained and poorly drained clayey soils. Botanical trails could include the poorly drained organic soils and the plant communities that grow on them. Level bedrock outcrops are desirable areas for placement of tables and fire grates.

Development and maintenance costs are high for intensive developments. The two major costs are water supply and disposal systems for sewage and solid waste. Water processing plants or costly bedrock wells are required. Standard septic tank systems are not acceptable in most areas; therefore lagoons, spray irrigation, sealed vaults, and similar systems are necessary. Due to extensive areas of soils that are shallow over bedrock and that have high coarse fragment content and sloping terrain, sanitary landfills have to be located in inextensive areas of deep loamy soils or outside the survey area.

Surface drainage systems must be well designed in intensive developments to prevent erosion of the soil, flooding of facilities, and damage to roads. Ponded water can attract insects. Size and location of surface drainage systems and culverts should be in accordance with the properties of the soils in which they are installed.

Vegetation needs to be maintained to retain or adjust desired vegetative cover. Unsurfaced areas that receive intensive use require a fertility program that includes recommendations for fertilization, lime, soil conditioner, and irrigation where feasible.

Sand beaches and shallow water are very uncommon in the Kawishiwi Area. Shorelines are commonly bedrock controlled, have deep waters, and are unfavorable for general swimming activities.

The soils are rated for several recreational uses in table 4. Explanations of the columns in table 4 are given in the following paragraphs.

Playgrounds and intensive play areas are designed for heavy use. They include fields for organized games. Some leveling and excavation are required.

Picnic and extensive play areas are developments designed for light use primarily by small groups for short periods. Play areas are prepared by clearing some trees and shrubs, but no artificial surfacing is used.

Trails and portages are cross-country hiking trails and canoe portages that have been cleared of vegetation and that have had some tread developed for user safety and erosion control.

Campgrounds are areas in which one or more of the following facilities have been developed: drinking water supplies, toilet facilities, camping units, parking areas, swimming beaches, and boat landings.

Wilderness campsites are areas in which the following facilities have been developed: access routes, fire

TABLE 4.—*Soil-recreation*

Soil series and map symbols	Playgrounds and intensive play areas	Picnic and extensive play areas	Trails and portages	Campgrounds	Wilderness campsites	Buildings	Sewage systems
Barto:							
BAC	Moderate: erosion hazard, compactibility, depth to bedrock.	Slight	Slight: compactibility.	Severe: erosion hazard, compactibility, depth to bedrock.	Moderate: depth to bedrock.	Moderate: depth to bedrock.	Severe: depth to bedrock.
BAC2	Moderate: erosion hazard, compactibility, depth to bedrock.	Slight	Slight: erosion hazard, compactibility.	Severe: erosion hazard, compactibility, depth to bedrock.	Moderate: depth to bedrock.	Moderate: depth to bedrock.	Severe: depth to bedrock.
BAE	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Moderate to severe: slope, erosion hazard.	Moderate: slope, erosion hazard, compactibility.	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Severe: slope, depth to bedrock.	Severe: slope, depth to bedrock.
Conic:							
COC	Slight to moderate: impermeable layer, compactibility, percolation.	Slight	Slight: compactibility.	Moderate to severe: impermeable layer, percolation, depth to bedrock.	Moderate: impermeable layer, compactibility, percolation.	Moderate: impermeable layer, percolation, depth to bedrock.	Severe: impermeable layer, percolation, depth to bedrock.
COE	Severe: slope, erosion hazard, impermeable layer, compactibility, percolation.	Moderate to severe: slope, erosion hazard.	Moderate to severe: slope, erosion hazard, impermeable layer, compactibility, percolation.	Severe: slope, erosion hazard, impermeable layer, compactibility, percolation, depth to bedrock.	Severe: slope, erosion hazard, impermeable layer, compactibility, percolation.	Severe: slope, impermeable layer, percolation, depth to bedrock.	Severe: slope, impermeable layer, percolation, depth to bedrock.
Indus: ID	Severe: compactibility, percolation, high water table.	Moderate: compactibility, high water table.	Severe: compactibility, percolation, high water table.	Severe: compactibility, percolation, high water table.	Severe: compactibility, percolation, high water table.	Severe: frost action, percolation, high water table.	Severe: percolation, high water table.
Insula:							
ISC	Moderate: compactibility, depth to bedrock.	Slight	Slight: compactibility.	Severe: erosion hazard, compactibility, depth to bedrock.	Moderate: depth to bedrock.	Moderate: depth to bedrock.	Severe: depth to bedrock.
ISC2	Moderate: compactibility, depth to bedrock.	Slight	Slight: erosion hazard, compactibility.	Severe: erosion hazard, compactibility, depth to bedrock.	Moderate: depth to bedrock.	Moderate: depth to bedrock.	Severe: slope, depth to bedrock.
ISE	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Moderate to severe: slope, erosion hazard.	Moderate: slope, erosion hazard, compactibility.	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Severe: slope, depth to bedrock.	Severe: depth to bedrock.

Mesaba: MEC	Slight to moderate: erosion hazard, compactibility, depth to bedrock.	Slight	Slight: compactibility.	Severe to moderate: compactibility, depth to bedrock.	Slight: compactibility.	Moderate: depth to bedrock.	Severe to moderate: depth to bedrock.
MEC2	Slight to moderate: erosion hazard, compactibility, depth to bedrock.	Slight	Slight: erosion hazard, compactibility.	Severe: erosion hazard, compactibility, depth to bedrock.	Slight to moderate: compactibility.	Moderate: depth to bedrock.	Severe to moderate: depth to bedrock.
MEE	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Moderate to severe: slope, erosion hazard.	Moderate to severe: slope, erosion hazard, compactibility.	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Severe: slope, erosion hazard, compactibility.	Severe: slope, depth to bedrock.	Severe: slope, depth to bedrock.
Mucky peats: MP	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.
Newfound: NFC	Slight to moderate: impermeable layer, compactibility, percolation.	Slight	Slight	Slight to moderate: impermeable layer, compactibility, percolation.	Slight	Slight to moderate: frost action, impermeable layer, percolation.	Moderate: impermeable layer, percolation.
NFE	Moderate to severe: slope, erosion hazard, impermeable layer, compactibility, percolation.	Moderate to severe: slope, erosion hazard.	Moderate: slope, erosion hazard, impermeable layer, percolation.	Severe: slope, erosion hazard, impermeable layer, compactibility, percolation.	Moderate to severe: slope, erosion hazard, impermeable layer, compactibility, percolation.	Moderate: frost action, slope, impermeable layer, percolation.	Moderate to severe: slope, impermeable layer.
Poorly drained loamy soils: PD.	Severe: compactibility, percolation, high water table.	Severe: percolation, high water table.	Moderate to severe: compactibility, percolation, high water table.	Severe: compactibility, percolation, high water table.	Severe: compactibility, percolation, high water table.	Severe: frost action, percolation, high water table.	Severe: percolation, high water table.
Quetico: QRC	Moderate to severe: erosion hazard, compactibility, depth to bedrock.	Moderate: depth to bedrock.	Slight: erosion hazard, compactibility.	Severe: erosion hazard, compactibility, depth to bedrock.	Moderate: depth to bedrock.	Moderate: depth to bedrock.	Severe: depth to bedrock.
QRE	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Severe: slope, erosion hazard, depth to bedrock.	Moderate: slope, erosion hazard, compactibility.	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Severe: slope, erosion hazard, compactibility, depth to bedrock.	Severe: slope, erosion hazard, depth to bedrock.	Severe: depth to bedrock.
Rubble land: RL	Severe: surface cobbles and stones.	Severe: surface cobbles and stones.	Moderate to severe: surface cobbles and stones.	Severe: surface cobbles and stones.	Severe: surface cobbles and stones.	Severe: surface cobbles and stones, high coarse fragment content.	Severe: percolation, high coarse fragment content.

TABLE 4.—*Soil-recreation*—Continued

Soil series and map symbols	Playground and intensive play areas	Picnic and extensive play areas	Trails and portages	Campgrounds	Wilderness campsites	Buildings	Sewage systems
Seelyeville: SE	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.
Waskish: WA	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.
Well drained loamy and gravelly soils: WD.	Slight to severe: slope, erosion hazard, compactibility.	Slight to moderate: slope.	Slight to moderate: slope, erosion hazard, compactibility.	Slight to severe: slope, erosion hazard, compactibility.	Slight to moderate: slope, erosion hazard, compactibility.	Slight to moderate: slope.	Slight to severe: slope, percolation.

grates, tent pads, and latrines. Development includes measures to ensure safety and protect resources.

Buildings are not more than two stories high and are used for administration and recreation.

Sewage systems are facilities, ranging from pit latrines to lagoons, that dispose of human waste.

Timber Management

Generally, the entire Kawishiwi Area has fair to poor potential for the production of pulpwood and poor potential for the production of sawtimber. This is because the soils are shallow over bedrock, have high coarse fragment content, and have a high water table in places.

Reforestation methods should minimize disturbance of the surface organic soil and the underlying mineral soil. Excessive disturbance can result in increased erosion, decreased available water capacity, enrichment of adjacent water bodies, loss of the most fertile part of the soil, reduced productivity potential, and possible permanent site deterioration. A major management concern on such very shallow soils as Quetico is the maintenance of vegetative cover.

Productivity is limited in the upland mineral soils by shallowness to bedrock, low natural fertility, seasonal droughtiness, restricted root development, moderate to severe windthrow hazard, and sloping to steep terrain. In lowland organic soils and poorly drained mineral soils, productivity is limited by a high water table, seasonal ponding, frost action, high content of cobbles and stones in mineral soils, and a severe windthrow hazard.

Use of heavy equipment should be restricted during the spring thaw and during periods of high rainfall. Proper planning and design of haul roads is necessary to minimize the ponding of water and subsequent vegetation dieoff, erosion, and removal of fill adjacent to the road.

In table 5, the soils are rated for various phases of timber management. Following are explanations of the columns in table 5.

Equipment restrictions are *slight* if the soils do not limit seasonal use of logging equipment. Restrictions are *moderate* if seasonal conditions limit equipment use and *severe* if the soils impose year-round limitations to the use of equipment.

Seedling mortality is the expected loss of natural or planted seedlings resulting from unfavorable soil characteristics, degree of wetness, or topographic position. Mortality is *slight* if the loss is less than 25 percent; *moderate* if loss is between 25 and 50 percent; and *severe* if loss is more than 50 percent.

Windthrow hazard is *slight* if trees blow over only during tornado or cyclonic winds. The hazard is *moderate* if pole-sized trees blow over during tornado or cyclonic winds but sawtimber blows over during above-normal winds. The hazard is *severe* if pole-sized and sawtimber trees blow over during above-normal winds.

Root restriction refers to limitations that the soil places on the development of deep tree roots.

Productivity for pulpwood and sawtimber is expressed in terms of site index. Soils that produce trees that have a site index of 66 or more have *very good* potential productivity; a site index of 56 to 65 indicates *good* potential productivity; a site index of 46 to 55 indicates *fair* potential productivity; and a site index of 45 or less indicates *poor* potential productivity.

Most of the terms in table 5 indicating soil characteristics that limit use for any purpose are self explanatory. Two, however, require further explanation. "Moisture stress" refers to situations in which the growing season is limited by a shortage of available moisture. "Dense surface cobbles and stones" refers to concentrations of coarse material on the soil surface.

Watershed

The hydrologic properties of the soils in the Kawishiwi Area are conducive to high water yield during spring melt and periods of high rainfall, high lake and stream levels in the spring, low water storage capacity, and low lake and stream levels in the fall. Shallow, pervious soils over bedrock; steep slopes; and high coarse fragment content in many soils are the major soil factors affecting water behavior in the Area.

Resource management practices can have a marked effect on water behavior in this Area. Extensive alteration of the vegetation could significantly affect runoff. Runoff could be increased or decreased with extensive removal or conversion of timber types.

The erosion hazard associated with the steep, shallow soils could contribute to sedimentation and to nutrient enrichment of water bodies. Erosion can be prevented and controlled by using such measures as water bars, surfaced or sodded road and diversion ditching, carefully located and properly sized culverts, and sodded road cuts and fills. Special care taken during construction helps to minimize erosion of raw cuts, fills, road ditches, and culvert excavations. Raw areas should not be allowed to remain unprotected for prolonged periods or through winter.

Special escorts in the generally shallow soils of the survey area to maintain or increase the thickness of the surface organic layer increase infiltration, reduce runoff, and increase water storage capacity.

Systems for acceptable treatment of sewage and solid waste are of major concern in the Area. Lakes and streams are quite sensitive to added nutrients; therefore extra precautions are needed to minimize any additions resulting from man's activities. Ineffective treatment could lead to long-term contribution of nutrients to lakes and streams.

Nutrients from natural sources are derived from annual leaf fall; erosion of mineral and organic soils; waste from moose, deer, bear, beaver, and numerous smaller animals; dust fallout; nutrients leaching out of the soil; and precipitation. The major contributor has yet to be determined.

Soil hydrological properties are presented in Table 6. More soil samples were collected from the Kawishiwi Barometer Watershed than from the Basswood-Knife Lake Watershed because of the barometer watershed's importance to water management in the Superior National Forest.

In table 6, the soils are placed in erodibility classes according to the following ratings: *I* indicates a low

TABLE 5.—

Soil series and map symbols	Depth to bedrock	Natural drainage	Equipment restrictions	Seedling mortality
	Inches			
Barto:				
BAC	8–20	Well drained	Slight	Slight: Low inherent fertility, potential moisture stress, depth to bedrock.
BAC2	8–20	Well drained	Slight	Slight to moderate: low inherent fertility; potential moisture stress, depth to bedrock.
BAE	8–20	Well drained	Moderate to severe: slope.	Slight to moderate: erosion hazard; low inherent fertility, potential moisture stress; depth to bedrock.
Conic:				
COC	20–40	Well drained	Slight	Slight: low inherent fertility, potential moisture stress.
COE	20–40	Well drained	Moderate to severe: slope.	Slight: erosion hazard, low inherent fertility, potential moisture stress.
Indus: ID	>40	Somewhat poorly drained to poorly drained.	Moderate: high water table.	Moderate: frost action, high water table, plant competition.
Insula:				
ISC	8–20	Well drained	Slight	Slight: low inherent fertility, potential moisture stress, depth to bedrock.
ISC2	8–20	Well drained	Slight	Slight to moderate: low inherent fertility, potential moisture stress, depth to bedrock.
ISE	8–20	Well drained	Moderate to severe: slope.	Slight: erosion hazard, low inherent fertility, potential moisture stress, depth to bedrock.
Mesaba:				
MEC	20–40	Well drained	Slight	Slight: low inherent fertility, potential moisture stress.
MEC2	20–40	Well drained	Slight	Slight to moderate: low inherent fertility, potential moisture stress.
MEE	20–40	Well drained	Moderate to severe: slope.	Slight: erosion hazard, low inherent fertility, potential moisture stress.
Mucky peats: MP	>51	Very poorly drained.	Moderate: high water table.	Severe: high water table
Newfound:				
NFC	>40	Well drained	Slight	Slight: low inherent fertility, potential moisture stress.

Soil-timber

Windthrow hazard	Root restriction	Productivity		Recommended species
		Pulpwood	Sawtimber	
Severe: depth to bedrock.	Moderate to severe: depth to bedrock.	Poor to fair	Poor	Jack pine, red pine, trembling aspen.
Severe: depth to bedrock.	Moderate to severe: depth to bedrock.	Poor	Poor	Jack pine, red pine, trembling aspen.
Severe: slope; depth to bedrock.	Moderate to severe: depth to bedrock.	Poor to fair	Poor	Jack pine, red pine, trembling aspen.
Moderate: impermeable layer, depth to bedrock.	Slight to moderate: impermeable layer, depth to bedrock.	Fair	Fair to poor	Jack pine, red pine, white spruce, trembling aspen, black spruce.
Moderate to severe: slope, impermeable layer, depth to bedrock.	Slight to moderate: impermeable layer, depth to bedrock.	Fair	Fair to poor	Jack pine, red pine, white spruce, trembling aspen, black spruce.
Severe to moderate: high water table.	Moderate to severe: high water table.	Very good to fair	Poor to fair	White-cedar, black ash, trembling aspen, white spruce.
Severe: depth to bedrock.	Moderate to severe: depth to bedrock.	Poor to fair	Poor	Jack pine, red pine, trembling aspen.
Severe: depth to bedrock.	Moderate to severe: depth to bedrock.	Poor	Poor	Jack pine, red pine, trembling aspen.
Severe: slope, depth to bedrock.	Moderate to severe: depth to bedrock.	Poor to fair	Poor	Jack pine, red pine, trembling aspen.
Moderate: impermeable layer, depth to bedrock.	Slight to moderate: impermeable layer, depth to bedrock.	Fair to good	Fair to poor	Jack pine, red pine, white spruce, black spruce, trembling aspen.
Moderate: impermeable layer, depth to bedrock.	Slight to moderate: impermeable layer, depth to bedrock.	Fair	Fair to poor	Jack pine, red pine, white spruce, black spruce, trembling aspen.
Moderate to severe: slope, depth to bedrock.	Slight to moderate	Fair to good	Fair to poor	Jack pine, red pine, white spruce, black spruce, trembling aspen.
Severe: high water table.	Severe: high water table.	Poor: high water table	Poor: high water table	Black spruce, white-cedar.
Moderate to severe: impermeable layer, high coarse fragment content.	Slight to moderate: impermeable layer.	Fair: impermeable layer.	Fair to poor: impermeable layer.	Red pine, jack pine, white spruce, white birch, trembling aspen.

TABLE 5.—*Soil-timber*

Soil series and map symbols	Depth to bedrock	Natural drainage	Equipment restrictions	Seedling mortality
	Inches			
Newfound—Continued				
NFE	>40	Well drained	Moderate: slope	Slight: erosion hazard, low inherent fertility, potential moisture stress.
Poorly drained loamy soils: PD	>40	Poorly drained	Moderate to severe: high water table.	Severe: frost action, high water table, plant competition.
Quetico:				
QRC	4–8	Somewhat excessively drained.	Slight to moderate: slope; depth to bedrock.	Moderate: low inherent fertility, potential moisture stress.
QRE	4–8	Somewhat excessively drained.	Moderate to severe: slope; depth to bedrock.	Moderate: erosion hazard, low inherent fertility, potential moisture stress.
Rubble land: RL	>40	Well drained to poorly drained.	Severe: dense surface cobbles and stones.	Severe: low inherent fertility, dense surface cobbles and stones, high coarse fragment content.
Seelyeville: SE	>51	Very poorly drained.	Moderate to severe: high water table.	Severe: high water table
Waskish: WA	>63	Very poorly drained.	Moderate to severe: high water table.	Severe: high water table
Well drained loamy and gravelly soils: WD.	>40	Well drained	Slight	Slight: low inherent fertility, potential moisture stress.

erosion hazard; *II*, moderately low; *III*, moderate; *IV*, moderately high; and *V*, high.

The soils are also placed in hydrologic groups in table 6. The groupings are based on estimates of the intake of water during the latter part of a storm of long duration. The estimates are of the intake of water in a soil without protective vegetation after the soil profile is wet and has swelled. The groups range from tight clays (highest runoff potential—Group D) to open sands (lowest runoff potential—Group A).

Available water capacity, expressed as inches of water per inch of soil, refers to the capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point.

Wildlife

The soils of the Kawishiwi Area have good potential for supporting manageable wildlife populations. There is considerable edge effect at natural soil boundaries.

Poorly drained soils in depressions are scattered throughout the Area. They add variety, have potential for pothole developments, and create natural edge effect. The natural drainageways support an abundance of beaver activity. Many drainageways have potential for developed water impoundments, and closeness to large bodies of water make them usable by waterfowl. Also, there is potential for development of spawning areas for northern pike.

Natural openings are common. Vegetation is varied and is comprised of plants suitable for food and shelter throughout the year. The principal plant species in the Area are listed in the section "Vegetation."

Animals common in the area are moose, white-tailed deer, black bear, beaver, and timber wolf. The moose and wolf populations are among the largest in the United States.

In table 7, the soils of the Kawishiwi Area are rated according to their potential for wildlife habitat. In table 7, the term "dense surface cobbles and stones" refers to concentrations of coarse material on the surface.

Ratings for plant composition are based on the following distinctions. A strongly varied plant community has forbs and shrubs under a tree canopy. A somewhat varied plant community has some forbs or some

—Continued

Windthrow hazard	Root restriction	Productivity		Recommended species
		Pulpwood	Sawtimber	
Moderate to severe: impermeable layer, high coarse fragment content.	Slight to moderate: impermeable layer.	Fair: impermeable layer.	Fair to poor: impermeable layer.	Red pine, jack pine, white spruce, white birch, trembling aspen.
Severe: high water table, dense surface cobbles and stones.	Severe: high water table, dense surface cobbles and stones.	Poor: high water table.	Poor: high water table	Black spruce, white spruce.
Severe: depth to bedrock.	Severe: depth to bedrock.	Poor: depth to bedrock	Poor: depth to bedrock.	Jack pine, white spruce, black spruce, balsam fir.
Severe: slope, depth to bedrock.	Severe: depth to bedrock.	Poor: depth to bedrock	Poor: depth to bedrock.	Jack pine, white spruce, black spruce, balsam fir.
Severe: dense surface cobbles and stones, high coarse fragment content.	Severe: low inherent fertility, dense surface cobbles and stones, high coarse fragment content.	Poor: low inherent fertility, dense surface cobbles and stones.	Poor: low inherent fertility, dense surface cobbles and stones.	Natural vegetation.
Severe: high water table.	Severe: high water table.	Poor: high water table	Poor: high water table	Black spruce, white-cedar.
Severe: high water table.	Severe: high water table.	Poor: high water table	Poor: high water table	Black spruce, white-cedar.
Slight	Slight	Fair to good: potential moisture stress.	Fair: potential moisture stress.	Red pine, jack pine, eastern white pine, trembling aspen, white spruce, black spruce.

shrubs under a tree canopy. A plant community of little variation has forbs but no shrubs under a tree canopy.

A food plot is a site that is managed to provide food for wildlife. A pothole is a water-filled excavation commonly smaller than 1 acre. An impoundment is a water body resulting from a manmade dam and is commonly larger than 1 acre.

Capability Grouping

Capability classification is the grouping of soils to show, in a general way, their suitability for field crops and pastures. It is a practical classification based on the limitations of the soils, the risk of damage when they are subjected to cultivation, and the way they respond to treatment. The classification does not apply to horticultural crops or to rice and other crops that have their own special requirements for economical production. The soils are classified according to degree and kind of permanent limitations, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils, and without consideration of possible major reclamation.

In the capability system, all the soils are grouped at three levels, capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest grouping, are designated by Roman numerals I through VIII. As the numerals increase they indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

- Class I soils have few limitations that restrict their use.
- Class II soils have some limitations that reduce the choice of plants or require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV soils have very severe limitations that restrict the choice of plants, require very careful management, or both.
- Class V soils are subject to little or no erosion but have other limitations, impractical to remove,

TABLE 6.—

[The symbol < means less than;

Soil	USDA texture	Depth to bedrock	Natural drainage	Depth to water table
		In		*Ft*
Barto: BAC, BAC2, BAE	Gravelly coarse sandy loam	8–20	Well drained	>6
Conic: COC, COE	Gravelly sandy loam	20–40	Well drained	>6
Indus: ID	Silty clay to clay	>40	Somewhat poorly drained to poorly drained.	<4
Insula: ISC, ISC2, ISE	Gravelly sandy loam	8–20	Well drained	>6
Mesaba: MEC, MEC2, MEE	Gravelly sandy loam	20–40	Well drained	>6
Mucky peats: MP	Mucky peat	>51	Very poorly drained	<2
Newfound: NFC, NFE	Gravelly sandy loam	>40	Well drained	>5
Poorly drained loamy soils: PD	Varied	>40	Poorly drained	<3
Quetico: QRC, QRE	Loam	4–8	Somewhat excessively drained.	>6
Rubble land: RL		>40	Well drained to poorly drained.	Variable
Seelyeville: SE	Muck	>51	Very poorly drained	<2
Waskish: WA	Peat	>63	Very poorly drained	<2
Well drained loamy and gravelly soils: WD.	Varied	>40	Well drained	>5

[1] Mor humus consists of a layer of largely organic matter abruptly distinct from the mineral soil beneath. Mull humus is a mixed layer of organic matter and mineral soils merging gradually into the mineral soil beneath.

[2] Permeability in Conic soils above a depth of 15 inches and below a depth of 26 inches is 2.0 to 6.0 inches per hour.

that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI soils have severe limitations that make them generally unsuitable for cultivation without major reclamation and limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VII soils have very severe limitations that make them unsuitable for cultivation without major reclamation and limit their use largely to range, woodland, or wildlife food and cover.

Class VIII soils and landforms have limitations that preclude their use for commercial plant production without major reclamation and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion; *w* shows that water on or in the soil interferes with plant growth or equipment operation; *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* shows that the chief limitation is climate that is too cold or too dry.

The capability classification of each soil in the Kawishiwi Area is given in the Guide to Mapping Units at the end of this survey.

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Hydrologic data

> means more than]

Fragipan	Humus type [1]	Erodibility class	Hydrologic group	Infiltration	Permeability	Available water capacity
				In per hr	*In per hr*	*In per in of soil*
No	Mor	III	B	0.15–0.3	2.0 – 6.0	0.10–0.14
Yes	Mor	III	B	0.15–0.3	[2] 0.06 – 0.2	[3] <0.10
No	Mull	III	D	0.05–0.15	0.2 – 0.6	0.16–0.20
No	Mor	III	B	0.15–0.3	2.0 – 6.0	0.10–0.14
No	Mor	III	B	0.15–0.3	2.0 – 6.0	0.10–0.14
No	---------------	I	D	------------------	2.0 – 6.0	0.35–0.50
Yes	Mor	III	B	0.15–0.3	[4] 0.06 – 0.2	[5] <0.10
No	Mull	III	B and C	0.05–0.3	0.2 – 2.0	0.10–0.15
No	Mor	III	D	------------------	0.6 – 2.0	0.10–0.18
No	---------------	I	A	------------------	------------------	
No	---------------	I	D	------------------	2.0 – 6.0	0.30–0.40
No	---------------	I	D	------------------	6.0 –20.0	0.45–0.60
No	Mor	III	B	0.15–0.3	0.6 –20.0	Variable.

[3] Available water capacity in Conic soils above a depth of 15 inches and below a depth of 26 inches is 0.10 to 0.14 inches per inch of soil.

[4] Permeability in Newfound soils above a depth of 16 inches is 2.0 to 6.0 inches per hour.

[5] Available water capacity in Newfound soils above a depth of 16 inches is 0.10 to 0.14 inches per inch of soil.

Glossary

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Compactibility. The ease with which soil free of vegetation can be formed into an unnatural cemented condition.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Fragipan. A loamy, brittle, subsurface horizon that is very low in organic matter content and clay but is rich in silt or very fine sand. The layer is seemingly cemented. When dry, it is hard or very hard and has a high bulk density in comparison with the horizon or horizons above it. When moist, the fragipan tends to rupture suddenly if pressure is applied, rather than to deform slowly. The layer is generally mottled, is slowly or very slowly permeable to water, and has a few or many bleached fracture planes that form polygons. Fragipans are a few inches to several feet thick; they generally occur below the B horizon, 15 to 40 inches below the surface.

Gleization. The reduction, translocation, and segregation of soil compounds, notably of iron, usually in the lower horizons, as a result of waterlogging with poor aeration and drainage; expressed in the soil by mottled colors dominated by gray. The soil forming processes leading to the development of a gley soil.

Gravel. Coarse materials three inches or less in diameter.

Lacustrine deposits. Lake-laid sediments.

Moisture stress. The growing season is limited by a shortage of available moisture.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The

TABLE 7.—

Soil series and map symbols	USDA texture	Depth to bedrock	Natural drainage	Depth to water table
		Inches		*Feet*
Barto:				
BAC	Gravelly coarse sandy loam	8–20	Well drained	>6
BAC2	Gravelly sandy loam	8–20	Well drained	>6
BAE	Gravelly sandy loam	8–20	Well drained	>6
Conic:				
COC	Gravelly sandy loam	20–40	Well drained	>6
COE	Gravelly sandy loam	20–40	Well drained	>6
Indus: ID	Silty clay to clay	>40	Somewhat poorly drained to poorly drained.	<4
Insula:				
ISC	Gravelly sandy loam	8–20	Well drained	>6
ISC2	Gravelly sandy loam	8–20	Well drained	>6
ISE	Gravelly sandy loam	8–20	Well drained	>6
Mesaba:				
MEC	Gravelly sandy loam	20–40	Well drained	>6
MEC2	Gravelly sandy loam	20–40	Well drained	>6
MEE	Gravelly sandy loam	20–40	Well drained	>6
Mucky peats: MP	Mucky peat (hemic)	>51	Very poorly drained	<2
Newfound:				
NFC	Gravelly sandy loam	>40	Well drained	>5
NFE	Gravelly sandy loam	>40	Well drained	>5

Soil-wildlife

Natural openings	Plant composition	Potential for— Food plot	Pothole	Impoundment
Common	Somewhat varied	Fair: low inherent fertility, potential moisture stress, depth to bedrock.	Poor: depth to bedrock	Poor: depth to bedrock.
Common	Somewhat varied	Fair to poor: low inherent fertility, potential moisture stress, depth to bedrock.	Poor: depth to bedrock	Poor: depth to bedrock.
Common	Somewhat varied	Fair: low inherent fertility, potential moisture stress, depth to bedrock.	Poor: slope, depth to bedrock.	Poor: slope, depth to bedrock.
Few to common	Somewhat varied	Fair: low inherent fertility, poor tilth, infiltration.	Poor: depth to bedrock	Poor: depth to bedrock.
Few to common	Somewhat varied	Fair: low inherent fertility, poor tilth, slope.	Poor: slope, depth to bedrock.	Poor: slope, depth to bedrock.
Common	Strongly varied	Fair to good: poor tilth, high water table, infiltration.	Good	Good.
Common	Somewhat varied	Fair: low inherent fertility, potential moisture stress, depth to bedrock.	Poor: depth to bedrock	Poor: depth to bedrock.
Common	Somewhat varied	Fair to poor: low inherent fertility, potential moisture stress, depth to bedrock.	Poor: depth to bedrock	Poor: depth to bedrock.
Common	Somewhat varied	Fair: low inherent fertility, potential moisture stress, slope, depth to bedrock.	Poor: slope, depth to bedrock.	Poor: slope, depth to bedrock.
Few	Somewhat varied	Good	Poor: infiltration, depth to bedrock.	Poor: infiltration, depth to bedrock.
Few	Somewhat varied	Good to fair: low inherent fertility.	Poor: infiltration, depth to bedrock.	Poor: infiltration, depth to bedrock.
Few	Somewhat varied	Good	Poor: slope, infiltration, depth to bedrock.	Poor: slope, infiltration, depth to bedrock.
Few	Strongly varied	Fair to good: high water table.	Fair to good	Fair to good.
Few	Somewhat varied	Fair to good: low inherent fertility, poor tilth.	Poor: infiltration	Poor: infiltration.
Few	Little variation	Fair to good: low inherent fertility, poor tilth.	Poor: slope, infiltration.	Poor: slope, infiltration.

TABLE 7.—

Soil series and map symbols	USDA texture	Depth to bedrock	Natural drainage	Depth to water table
		Inches		*Feet*
Poorly drained loamy soils: PD	Varied	>40	Poorly drained	<3
Quetico:				
QRC	Loam	4–8	Somewhat excessively drained.	>6
QRE	Loam	4–8	Somewhat excessively drained.	>6
Rubble land: RL		>40	Well drained to poorly drained.	1 to 3
Seelyeville: SE	Muck (sapric)	>51	Very poorly drained	<2
Waskish: WA	Peat (fibric)	>63	Very poorly drained	<2
Well drained loamy and gravelly soils: WD.	Varied	>40	Well drained	>5

principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportions of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Varves. Distinctly marked annual deposits of sediments, regardless of their origin.

Water storage capacity. The relative capacity of a soil to retain water and release it to water systems throughout the year.

Water yield potential. The relative potential of a soil to release water to subsurface and surface water systems.

Watershed. An area drained by a river or a river system.

Soil-wildlife—Continued

Natural openings	Plant composition	Potential for—		
		Food plot	Pothole	Impoundment
Common to many	Strongly varied	Fair to good: poor tilth, dense surface cobbles and stones, high water table.	Fair to good	Fair to good.
Many	Little variation	Poor: low inherent fertility, potential moisture stress, depth to bedrock.	Poor: low inherent fertility, depth to bedrock.	Poor: low inherent fertility, depth to bedrock.
Many	Little variation	Poor: low inherent fertility, potential moisture stress, slope, infiltration.	Poor: slope, depth to bedrock.	Poor: slope, depth to bedrock.
Many	Little variation	Poor: low inherent fertility, poor tilth, dense surface cobbles and stones.	Poor: infiltration, dense surface cobbles and stones.	Poor: infiltration, dense surface cobbles and stones.
Few	Little variation	Poor: low inherent fertility, high water table.	Fair to good	Good.
Few	Little variation	Poor: low inherent fertility, high water table.	Poor: low inherent fertility.	Fair: low inherent fertility.
Few	Somewhat varied	Fair: low inherent fertility, potential moisture stress.	Poor: infiltration	Poor: infiltration.

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GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which it is a part. For information about the capability classification system, see page 29.

Map symbol	Mapping unit	Described on page	Capability subclass Symbol
BAC	Barto gravelly coarse sandy loam, 2 to 18 percent slopes	7	VIs
BAC2	Barto gravelly coarse sandy loam, 2 to 18 percent slopes, disturbed	7	VIs
BAE	Barto gravelly coarse sandy loam, 18 to 35 percent slopes	7	VIIs
COC	Conic gravelly sandy loam, 2 to 18 percent slopes	8	IVs
COE	Conic gravelly sandy loam, 18 to 35 percent slopes	8	VIIe
ID	Indus silty clay	9	IIIw
ISC	Insula gravelly sandy loam, 2 to 18 percent slopes	9	VIs
ISC2	Insula gravelly sandy loam, 2 to 18 percent slopes, disturbed	10	VIs
ISE	Insula gravelly sandy loam, 18 to 35 percent slopes	10	VIIs
MEC	Mesaba gravelly sandy loam, 2 to 18 percent slopes	11	IVs
MEC2	Mesaba gravelly sandy loam, 2 to 18 percent slopes, disturbed	11	IVs
MEE	Mesaba gravelly sandy loam, 18 to 35 percent slopes	12	VIIe
MP	Mucky peats	12	VIIw
NFC	Newfound gravelly sandy loam, 2 to 18 percent slopes	13	IVs
NFE	Newfound gravelly sandy loam, 18 to 25 percent slopes	13	VIe
PD	Poorly drained loamy soils	13	VIIs
QRC	Quetico-Rock outcrop complex, 5 to 18 percent slopes	14	VIIs
QRE	Quetico-Rock outcrop complex, 18 to 35 percent slopes	15	VIIs
RL	Rubble land	15	VIIIs
SE	Seelyeville muck	16	IVw
WA	Waskish peat	17	VIIw
WD	Well drained loamy and gravelly soils	17	VIs

Accessibility Statement