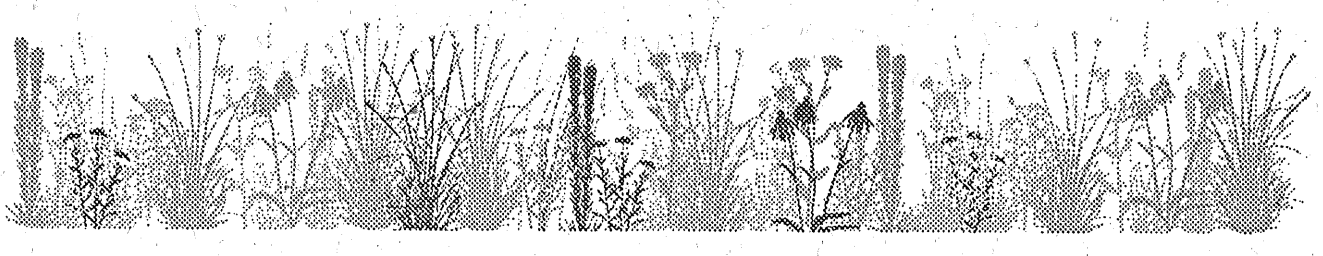
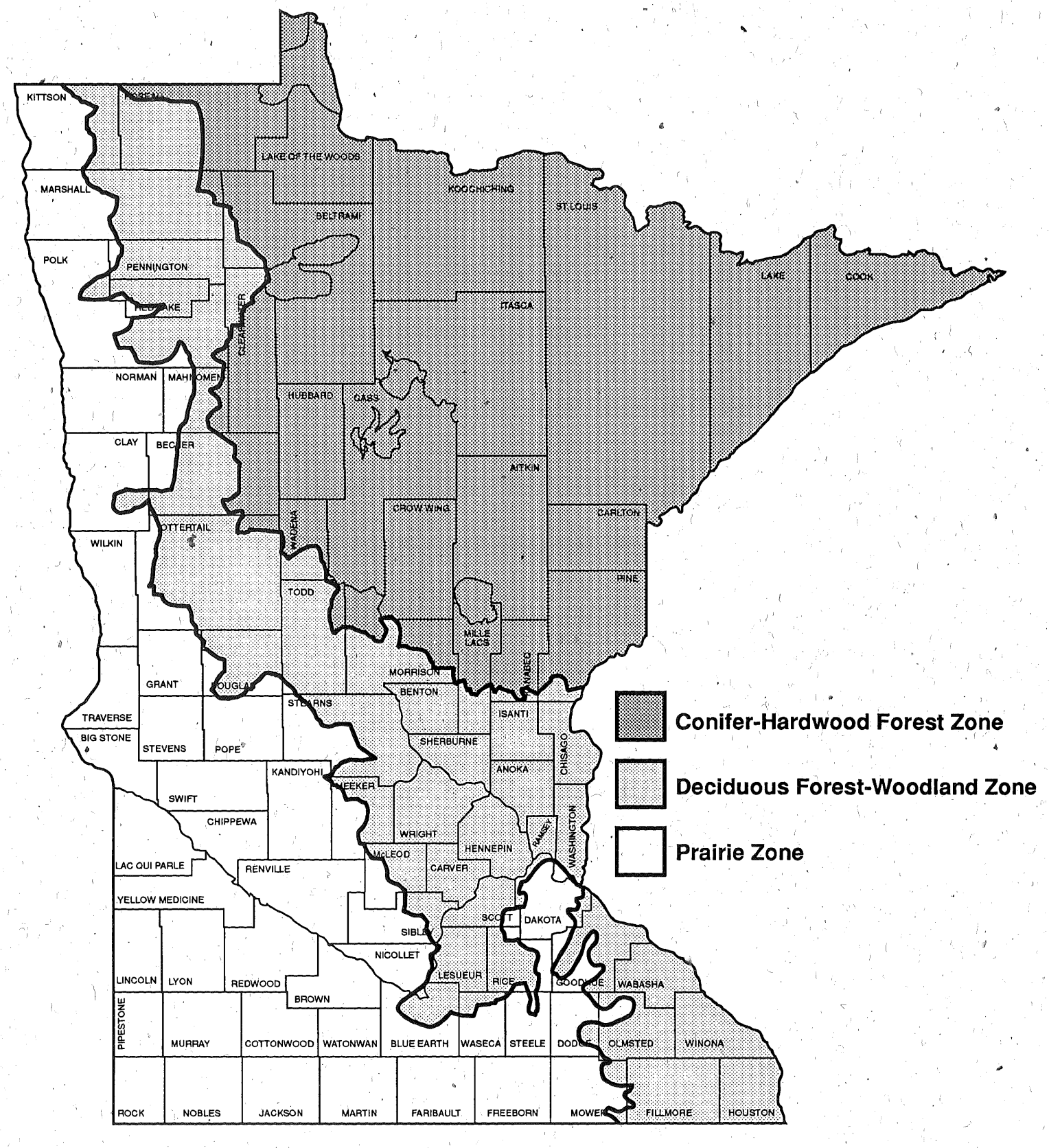
Minnesota's Native Vegetation:



A Key to Natural Communities

Version 1.5

Figure 1. The Conifer-Hardwood Forest, Deciduous Forest-Woodland and Prairie Zones of Minnesota.



MINNESOTA'S NATIVE VEGETATION

A Key to Natural Communities

Version 1.5

Minnesota Department of Natural Resources

Natural Heritage Program

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PREFATORY NOTE

This version of *Minnesota's Native Vegetation: a Key to Natural Communities* contains changes that have been made to the Natural Heritage Program's natural community classification since the production of the previous version (Version 1.4). The key will continue to be updated periodically as new information becomes available. We would appreciate any comments you have on the key as you use it. Please address them to:

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INTRODUCTION

This key is a revision and expansion of "A Preliminary Classification and Description of Natural Communities in Minnesota", compiled in 1984 by Keith Wendt, plant ecologist with the Natural Heritage Program. Wendt developed his classification mainly from existing literature on plant communities in Minnesota and adjacent states (especially Wisconsin). The classification was designed primarily as a tool for recognizing and preserving important natural ecosystems in Minnesota.

Since the development of Wendt's classification, a significant amount of new field data has been collected on Minnesota's vegetation and on abiotic habitat features. Most of this information has come from two new inventory projects, the Minnesota County Biological Survey (MCBS) and the Minnesota Vegetation Database (Releve System). These two inventory projects necessitated that Minnesota's natural communities be: 1) defined in a clear manner (even if somewhat arbitrarily in certain cases), 2) recognizeable from aerial photographs, 3) mapped at a county scale, and 4) relatively consistent with multivariate classifications of standardized vegetation plot samples. The earlier preservation-based classification did not necessarily treat natural communities according to these guidelines, making it less useful as an aid to conducting these new inventories. For this reason, revision was begun on the Natural Heritage Program's natural community classification and key.

This new natural community key classifies and describes recurrent natural units of Minnesota's landscape by considering vegetation, topography, hydrology, landforms, substrates, soils, and natural disturbance regimes. Of these features, vascular vegetation is weighted most heavily. Abiotic features of the landscape are included in community descriptions where they correlate with the distributions of vascular plants in the community and where their effect on the ecology of the community is well understood.

The key is hierarchical, describing Systems, Classes, and Types of Natural Communities, respectively (see nomenclature below). Four Systems, nineteen Classes, and fifty-six Types appear in the key. The field data used to construct the new key comprise over 1,100 computerized records of natural communities from more than 1,000 vegetation plots. These data now exist in the Natural Heritage Program information system.

In general, the key provides a comprehensive and unambiguous means of identifying communities to the **Type** level. Community differentiation below the type level is treated less rigorously. Where there is known to be consistent geographic variation in a natural community type, the type may be subdivided into geographic **Sections**; however, better data are needed on the constituent species and statewide distributions of communities before reliable and exhaustive lists of geographic sections can be made for each natural community type. Where information is known on variation within a community type that is related to abiotic features of the environment (such as soil moisture or groundwater seepage), the community type may be further divided into **Subtypes**. As was the case for sections, because of a lack of comprehensive information the list of subtypes identified for a given community type is not necessarily

exhaustive (unless indicated--see Appendix 1).

The community types, sections, and subtypes listed in this key will be added to and revised as a result of the ongoing work of the Minnesota County Biological Survey. The final version will appear at the completion of the Survey (approximately AD 2010), at which time the distinctiveness of the communities--on aerial photographs, on satellite imagery, and in the field--will have been tested statewide. We invite anyone interested in the natural vegetation and native plants of Minnesota to participate in the refinement of this key. Plot data, computer facilities, and software are available for projects that will contribute significant information to the key.

NATURAL COMMUNITY NOMENCLATURE AND GENERAL CRITERIA

System -- Systems are based primarily on water regimes (that is, the interaction of landforms with the water table). Wetland systems are classified according to Cowardin[1] (palustrine, lacustrine, and riverine.) All non-wetland systems are classified as terrestrial systems. The names of the systems are not used in constructing the names of the natural communities in the key.

Class -- Natural community classes are designed to meet the natural community inventory and mapping needs of the Minnesota County Biological Survey and the Natural Heritage Program. Classes are identifiable from aerial photographs and sometimes from satellite imagery. The features used to define natural community classes are:

1. the water regime, including the source and chemistry of water and its seasonal availability to plants

2. the physiognomy of the vegetation, particularly the distribution, height, and cover of woody plants

3. the life form of the dominant cover species

4. landforms and associated soils

Class names are not used in forming the names of the natural communities (but they are used by MCBS ecologists as map-unit designators when identification to type is not possible.)

Type -- Natural community types are designed to meet needs for conservation planning, quantitative vegetation analysis, and expressing patterns of vegetation at a local (county) scale. Many natural community types can be identified from aerial photographs or a combination of aerial photographs, topographic maps, and soils maps. Other natural community types can be identified reliably only in the field. Some of the criteria used in defining natural community

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[1]Cowardin, L.M., V. Carter, F.G. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Washington, D.C.

classes are also used in defining natural community types, however types are defined primarily by their dominant cover-forming plant species.

Type names form the root of natural community names.

e.g., ***Wet Prairie***

Subtype -- Subtypes describe variability within a natural community type that is evident from multivariate analyses of plot samples or that is obviously related to successional stage or to abiotic habitat features such as substrate composition or water chemistry.

Subtypes are appended to the natural community type names.

e.g., ***Wet Prairie*** *Seepage Subtype*

Section -- Sections identify consistent geographical variability within a natural community type. Sections may be based on the range limits of important species in the community, major landform or glacial drift types, climatic zones, or other features that vary regionally (over several counties).

Section names are parenthetical and are appended directly after the natural community type name and before the subtype name.

e.g., ***Wet Prairie*** *(Northwest Section) Seepage Subtype*

SCHEMATIC OF HIERARCHY AND CRITERIA

System
water regime
.
.
.....**Class**
water regime
vegetation physiognomy
life form of dominant plants
landforms and associated soils
.
.
.....**Type**.....**Section**
dominant cover species — regional plant geography
indicator species — climatic regions
. — regional geology
.
.....**Subtype**
substrate
water chemistry
successional stage

KEY TO THE NATURAL COMMUNITY SYSTEMS AND CLASSES

A. Habitat not flooded or saturated by groundwater for more than a few days during a normal year; vegetation always dominated by non-hydrophytic plants (Appendices 2 and 3); evidence of flooding, such as windrows of debris, raised root systems, ice scars, or peaty soil, is absent; soils predominantly mineral and without hydric characteristics (i.e., gleying or mottling) ..... **TERRESTRIAL SYSTEM** .... **1.**

1. mature trees (Appendix 2) present (>10% total cover) ..... **2.**

2. trees form closed stands (>70% total cover) ..... **FOREST** ..... **3.**

3. tree cover <20% coniferous trees (i.e., >80% broad-leaved deciduous trees) .. .. page 12, **Deciduous Forest**

3. tree cover >20% coniferous trees ..... **4.**

4. tree cover >80% coniferous trees ..... page 21, **Coniferous Forest**

4. tree cover <80% coniferous trees .... page 27, **Mixed Coniferous-Deciduous Forest**

2. tree canopy broken to scattered (10-70% total cover), surrounding matrix either brush, prairie, or a primary community ..... **SAVANNA OR WOODLAND** .... **5.**

5. trees mostly deciduous; community of the deciduous forest-woodland zone (Fig. 1) ..... **6.**

6. matrix surrounding trees <30% open grassland or primary communities; tall brush cover generally dense ..... page 30, **Deciduous Woodland**

6. matrix surrounding trees >30% open grassland or primary communities; tall brush cover generally sparse ..... page 33, **Deciduous Savanna**

5. trees mostly coniferous; community of the conifer-hardwood forest zone (Fig. 1) ..... **7.**

7. matrix surrounding trees <30% open grassland or primary communities; tall brush cover generally dense ..... page 39, **Coniferous Woodland**

7. matrix surrounding trees >30% open grassland or primary communities; tall brush cover generally sparse ..... page 41, **Coniferous Savanna**

1. mature trees absent (<10% total cover) .. **PRAIRIE/PRIMARY COMMUNITY** .... **8.**

8. ground with >30% cover of persistent vascular plants; most plants with prairie affinity (Appendix 3) ..... **9.**

9. vascular plant cover >30% brush ..... page 43, **Upland Brush-Prairie**

9. vascular plant cover <30% brush ..... page 46, **Upland Prairie**

8. ground with <30% cover of persistent vascular plants; plants with or without prairie affinity; mosses and lichens often abundant; rock or sand substrate ..... page 76, **Primary Community**

A. Habitat usually flooded or saturated by groundwater such that the vegetation contains at least some hydrophytic plants (Appendix 4) and, occasionally, aquatic plants (Appendix 5); evidence of flooding (such as debris windrows, raised root systems, ice scars, or peaty soil) is present in some communities; soils typically have some hydric characteristics (i.e., gleying or mottling) ..... **WETLAND .... B.**

B. a wetland with persistent emergent vascular plants, trees, shrubs, or emergent mosses covering more than 30% of its area ..... **PALUSTRINE SYSTEM .... 10.**

10. raised peatland formed by the accumulation of sphagnum moss; has characteristic landforms (dome, crest, or ovoid island) often evident on aerial photos as radiating lines of trees and open drains in large peatlands; water input primarily from precipitation ... . page 53, **Bog**

10. level or sloping wetland, not raised; domes, crests, or ovoid islands present or absent; substrate peat or mineral soil; water input from both groundwater and precipitation ..... **11.**

11. tree cover >30% ..... **FORESTED WETLAND .... 12.**

12. site subject to seasonal or otherwise periodic inundation or saturation; soils composed of mineral matter, typically have signs of alternating wet and dry cycles, such as mottling ..... **13.**

13. situated between an upland and a peatland, along the margin of a closed basin, or on an inactive floodplain ..... page 19, **Lowland Hardwood Forest**

13. situated on an active floodplain of a river or stream; evidence of flooding, such as debris dams, ice scars, silt deposits, etc., typically present ..... page 56, **Floodplain Forest**

12. area typically at or below the local water table, rarely drying; soils composed

primarily of accumulated organic matter (peat); soils lack signs of alternating wet and dry cycles ..... **14.**

14. tree cover mostly deciduous ..... page 59, **Hardwood Swamp Forest**

14. tree cover mostly coniferous ..... page 62, **Conifer Swamp Forest**

11. tree cover <30% .....**OPEN WETLAND** .... **15.**

15. tall (>2m) shrub cover (excludes ericaceous shrubs) interrupted to continuous (>70% cover) ..... page 65, **Shrub Swamp**

15. tall (>2m) shrub cover (excludes ericaceous shrubs), open to patchy (<70% cover) .....**16.**

16. stands of tall (>1m) graminoids; shrubs generally absent or if present have <30% cover; graminoids emergent from standing water during some or all of the growing season; canopy often broken, pools or channels typically evident; obligate aquatic plants (Appendix 5) usually present ....page 67, **Emergent Marsh**

16. stands of short to mid-sized (generally <1m) graminoids; shrubs present or absent (includes types ranging from entirely herbaceous, to mixed shrubs and herbs with up to 70% shrub cover); graminoids usually growing from the surface of saturated peat or moist mineral soil; canopy usually closed; obligate aquatic species (Appendix 5) mostly absent, however, facultative aquatic species often present in subcanopy ..... page 69, **Wet Meadow/Fen**

B. a wetland where persistent emergents, trees, shrubs, or emergent mosses cover less than 30% of the area; however, nonpersistent emergents and submergents can be seasonally abundant .....**SHALLOW AQUATIC OR SHORELINE COMMUNITY** .... **C.**

C. area situated in a channel; flowing water is usually present ....**RIVERINE SYSTEM** .... **17.**

17. area between normal water line and flood line .... page 76, **Primary Community**

17. area normally submerged ..... page 83, **Aquatic River Community**

C. area situated in a basin, a catchment, or on level or sloping ground; standing water usually present ..... **LACUSTRINE SYSTEM** .... **18.**

18. area between normal water line and flood line .... page 76, **Primary Community**

18. area normally submerged ..... page 84, **Aquatic Lake Community**

DECIDUOUS FOREST

Deciduous Forests occur primarily in the deciduous forest-woodland zone (Fig. 1); they are less common in the prairie zone and the conifer-hardwood forest zone. On dry sites, the most common canopy dominants of Deciduous Forests are oak, aspen, and birch trees. Sugar maple, basswood, elm, and ash trees are common dominants on moist sites. Pines, especially white pine, sometimes form a minor part of the forest canopy. Where the forest canopy is broken or interrupted (typically in oak-dominated forests) there is usually a dense layer of tall shrubs, including hazelnuts, dogwoods, prickly ashes, and cherries. Beneath the denser canopies formed by mesic tree species such as sugar maple, the shrub layer is sparse or absent.

The canopy tree species of Deciduous Forests occur in combinations determined primarily by environmental features (including soil texture, parent material, presence of hardpans and firebreaks, depth to the water table, topography, aspect, and local climate) that affect soil moisture and the local fire regime. These features produce a gradient of Deciduous Forest types from dry, fire-prone forests composed of fire-adapted species, to mesic forests composed of fire-sensitive species.

Many of the dry Deciduous Forests in the deciduous forest-woodland and prairie zones appear to have succeeded from deciduous brushland and savanna in the past 100 to 125 years following widespread forest fragmentation and fire suppression. Mesic Deciduous Forests in these zones occur in areas protected from fire, especially areas of rough topography and along bodies of water. In the conifer-hardwood forest zone, mesic Deciduous Forests occur on sites with impeded drainage (having impermeable banding or textural pans in the soils) and in areas of locally high precipitation or humidity, such as along the shore of Lake Superior. The dry deciduous forests of the conifer-hardwood zone, especially Aspen, Aspen-Birch, and Paper Birch forests, occur on fire-prone sites and are considered early successional communities.

There are seven Deciduous Forest community types in Minnesota. These were determined principally by literature surveys and interpretations of land survey records.

a. tree cover mostly quaking aspen, big-toothed aspen, paper birch, red maple, or oak; habitat dry to dry-mesic; early to mid-successional communities; dominant canopy trees often the same age, having germinated following disturbances such as fire, windthrow, disease epidemic, or logging ..... **b.**

b. tree cover >70% aspen or paper birch, generally <30% oak; understory highly variable ..... **c.**

c. tree cover dominated by aspen; paper birch absent in stands on prairie soils or a minor associate (<5% cover) in stands on forest soils; oaks and green ash are common associates (<30% cover); a community of the prairie zone or deciduous forest-woodland zone (Fig. 1) ..... ***Aspen Forest***

c. tree cover dominated by aspen or paper birch or a combination of these species, with each having > 10% cover; a community of the conifer-hardwood forest zone or an outlier in the deciduous forest-woodland zone (Fig.1)..... ***Aspen-Birch Forest***

c. tree cover dominated by paper birch; aspen absent or contributing less than 10% of the canopy cover; a community of the conifer-hardwood forest zone or an outlier in the deciduous forest-woodland zone (Fig. 1) ..... ***Paper-Birch Forest***

b. tree cover <70% aspen and paper birch, and generally >30% oak, typically mixed with other trees; understory in older stands often includes some saplings of mesic trees .... ***Oak Forest***

a. tree cover mostly sugar maple, basswood, yellow birch, green ash, American elm, or slippery elm; northern red oak sometimes important in the canopy; habitat mesic to wet-mesic; mid- to late-successional communities; dominant canopy trees typically not the same age, having germinated following fine-scale disturbances such as treefall gaps; evidence of widespread disturbances such as fire or windthrow is rare ..... **d.**

d. tree cover mostly sugar maple or basswood, or a mixture of the two; minor canopy species are northern red oak in drier habitats and ash, elm, or yellow birch in wetter habitats .....**e.**

e. tree cover up to 20% coniferous species, or if previously logged, conifers present in understory; groundlayer often includes herbs associated with acid conifer litter (mor humus) ..... ***Northern Hardwood Forest***

e. tree canopy without conifers or with scattered white pine; generally no pine reproduction in understory; groundlayer dominated by herbs associated with mull humus .....***Maple-Basswood Forest***

d. tree cover mostly black ash, green ash, yellow birch, red maple, or elm; habitat wet-mesic; soils often mottled within tree rooting zone but not at the ground surface; groundlayer dominated by upland herbs; hydrophytic species (Appendices 4 and 5) mostly absent ....***Lowland Hardwood Forest***

Aspen Forest

Aspen Forest occurs throughout the deciduous forest-woodland zone, with isolated patches in the prairie zone (Fig. 1). The community develops primarily on sites with wet, poorly drained soils and high water tables, although the water table is usually not high enough to affect the groundlayer composition of the community or to cause peat accumulation.

The tree canopy most often is dominated by quaking aspens. Paper birches, balsam poplars,

bur oaks, pin oaks, green ashes, or basswoods are minor canopy trees, although they may be abundant in the understory as seedlings and saplings. On low, poorly drained sites balsam poplars are sometimes more abundant than quaking aspens in the tree canopy.

The understory of Aspen Forests tends to be brushy. American hazelnut is almost always abundant in the understory. Other shrubs vary in presence and abundance with soil moisture, which ranges from wet-mesic to dry. The groundlayer is composed mostly of forest herbs and grasses capable of surviving in the shade under the dense shrub layer. These species include wild sarsaparilla (*Aralia nudicaulis*), Canada mayflower (*Maianthemum canadense*), the sedge *Carex pensylvanica*, false melic grass (*Schizachne purpurascens*), and mountain rice-grass (*Oryzopsis asperifolia*).

Aspen Forest is an early-successional community. With prolonged absence of fire or other disturbances, Aspen Forests succeed to mid-successional forests composed of the minor canopy tree species listed above. An analysis of land survey records indicates that relatively pure stands of quaking aspen historically occurred on level terrain rather than on rough topography, suggesting that these stands were maintained by fire and windthrow. The aspen trees were present most commonly on somewhat poorly drained mineral soils, especially drumlin fields and other landforms with heavy soils, while paper birch, pin oak, and bur oak trees associated with the aspens were probably present on local areas of better drained soils.

Plots of aspen trees from early public land survey records show that aspen also occurred on areas of relict prairie soils within the deciduous forest-woodland zone. These sites are now mainly forested, but the land survey records indicate that the aspen trees previously were scattered widely enough on them to constitute woodland rather than forest. This is consistent with the surveyors' written descriptions of these sites, which state that they had relatively dense shrub layers dominated by American hazelnut, and groundlayers dominated by prairie forbs and graminoids. Aspen forests that occur on prairie soils and have prairie understories eventually may be recognized as a subtype of Aspen Forest or as a phase of Aspen Woodland, following further research and analysis of survey records. No sections of Aspen Forest are anticipated.

Aspen-Birch Forest

Aspen-Birch Forest occurs almost exclusively on upland sites in the conifer-hardwood forest zone (Figure 1). The community is dominated by trees of quaking aspen, bigtooth aspen (typically in clones), and paper birch, with at least 10% of the canopy cover made up of either aspen or birch. The tall-shrub layer tends to be dense and is most often composed of beaked hazel, mountain maple, and saplings of late-successional tree species. The groundlayer is usually very diverse.

Aspen-Birch Forest is an early successional community that originates following catastrophic disturbances, especially fire and clear-cutting. In the absence of catastrophic disturbances, Aspen-Birch Forest may succeed to Spruce-Fir Forest, Boreal Hardwood-Conifer Forest, Northern Hardwood Forest, Northern Hardwood-Conifer Forest, Maple-Basswood Forest, or

even Upland White Cedar Forest. Where white pine is present in the understory, Aspen-Birch Forest may succeed to White Pine Forest.

Aspen-Birch Forest now covers a large portion of northern Minnesota because of logging and repeated post-logging fires, which eliminated most of the local pine seed sources. There are two recognized subtypes: the Spruce-Fir Subtype in which saplings of balsam fir or white spruce are conspicuous in the understory, and the Northern Hardwoods Subtype in which saplings of sugar maple and other northern hardwoods are conspicuous in the understory.

Paper Birch Forest

Paper Birch Forest occurs primarily in the conifer-hardwood zone, especially in northeastern Minnesota, with small stands present also on shaded north-facing slopes in the deciduous forest-woodland zone (Fig. 1). The canopy of Paper Birch Forests is strongly domminated by paper birch trees. The tall-shrub layer typically contains beaked hazel and mountain maple. Seedlings and saplings of mid- and late-successional tree species are often present in the understory; balsam fir is an especially common understory species in northeastern Minnesota. Little data are available on the groundlayer composition of the community, especially in regard to how it may differ from that of the closely related Aspen-Birch Forest community. However, blue-bead lily (*Clintonia borealis*), stiff clubmoss (*Lycopodium annotinum*), and mosses appear to be more common in Paper Birch Forests, while large-leaved aster (*Aster macrophyllus*) is more common in Aspen-Birch Forests.

Paper Birch Forest usually originate following fire. In the absence of disturbance the community tends to succeed to many of the community types to which Aspen-Birch Forest succeeds (see above). Like Aspen-Birch Forest, Paper Birch Forest has a Spruce-Fir Subtype and a Northern Hardwoods Subtype.

Oak Forest

Oak Forest is widespread in Minnesota. It is most common on dry to dry-mesic sites in the deciduous forest-woodland zone (Fig. 1) but also occurs occasionally in the southern and western parts of the conifer-hardwood zone, and in stream valleys in the prairie zone.

At least 30% of the tree canopy in an Oak Forest is made up of oak trees. Most often aspen, paper birch, or black cherry trees make up the remainder of the canopy. The actual composition of the community, however, varies considerably in response to variation in soil moisture, soil type, fire history, and climate. The driest stands of Oak Forest are dominated by northern pin oaks and white oaks, with black oaks, shagbark hickories, and sometimes bur oaks important in southeastern Minnesota. These stands occur on nutrient-poor, well-drained sandy soils on outwash plains, river terraces, and beach ridges. They have relatively open canopies, with between 70% and 80% cover. The canopy height is usually between 13 and 17 meters.

Because of the open canopy, the shrub layer is often very dense. American hazel dominates the shrub layer, which also often contains gray-bark dogwood, blueberries, and blackberries. Some of the more common groundlayer species are the sedge (*Carex pensylvanica*), wild geranium (*Geranium maculatum*), Virginia creeper (*Parthenocissus inserta*), wild sarsaparilla (*Aralia nudicaulis*), and hog-peanut (*Amphicarpa bracteata*).

Commonly, at least some of the oak trees in the dry stands have multiple stems and thick, spreading lower branches, indicating that these trees grew up in a disturbed and more open setting. Minnesota public land survey records indicate, in fact, that many of these dry stands were oak savanna or oak woodland before European settlement and with fire suppression have succeeded to forest. Oak regeneration is rare in these stands now, as the oak species reproduce poorly under forest canopies. In the absence of fire, relatively mesic or fire-sensitive species such as bitternut hickory, basswood, and red maple, are increasing in abundance in the community.

Northern red oaks, white oaks, or bur oaks dominate the more mesic stands of Oak Forest are dominated by . These stands occur on sites that had fewer severe fires before European settlement than the sites on which dry Mixed Oak Forest occurs. These mesic stands most likely were always forest, rather than woodland or savanna. They have tall (> 20 meters), straight, single-stemmed trees that lack spreading lower branches. Commonly, mesic fire-sensitive tree species are present with the oaks in these stands, especially in the understory. These species include basswood, green ash, bitternut hickory, big-toothed aspen, and butternut.

The shrub layer in mesic stands is sparser than in dry stands and, correspondingly, the forb layer is denser and more diverse and there are more graminoid species. Like the drier stands, however, there is little oak regeneration, and most mesic Oak Forests appear to be succeeding to Maple-Basswood forest. Heavy selective logging of the oaks in mesic stands may accelerate this trend, producing young stands of Maple-Basswood Forest. The mesic stands often grade into drier stands of Maple-Basswood Forest, but differ from them by having a somewhat denser shrub layer and the herbs woodrush (*Luzula acuminata*) and pointed-leaved tick-trefoil (*Desmodium glutinosum*) in their understory.

Another variant of Oak Forest occurs in northeastern Minnesota, principally on ridgetops and upper slopes, where the forest intermingles with bedrock outcrops. These forests contain northern red oak, bur oak, pin oak, and red maple. They originated mainly following the logging and burning of stands of Red Pine Forest in the 1800s and early 1900s.

In general, most existing stands of Oak Forest have been disturbed by grazing or selective cutting, or have been fragmented by development. Natural stands of mesic Mixed Oak Forest are rare. Drier stands are more common, in part because relative to the mesic forests they occur on sites with soils less suitable for cultivation. Additionally, dry Oak Forests may have increased in extent somewhat following fire suppression, succeeding from oak savanna and woodland. Disturbed stands of oak forest commonly have dense subcanopies of prickly ash, or of the exotic species common buckthorn and Tartarian honeysuckle, which have also now invaded many undisturbed stands. Disturbance through grazing may also be partly responsible

for the lack of regeneration in Oak Forests, especially in stands with heavy soils that compact readily with trampling.

Oak Forest is divided geographically into Southeast, Big Woods, Central, Northwest, and Northeast Sections (Fig. 2). There are also three recognized subtypes (Dry, Mesic, and Red Maple), corresponding to the floristic and structural variation in the community described above.

Northern Hardwood Forest

Northern Hardwood Forest is a mesic forest community present mainly in the conifer-hardwood forest zone (Fig. 1), with small stands on the Paleozoic Plateau in southeastern Minnesota (Fig. 3). The canopy is dominated by dry-mesic to mesic hardwoods, especially sugar maple, basswood, and yellow birch. Northern red oak may be codominant in the canopy on drier sites; black ash and American elm may be codominant on wetter sites. Northern Hardwood Forest shares many of its tree species with Maple-Basswood Forest but differs from Maple-Basswood Forest by having a significant conifer component, including white pine (now present most often as stumps), balsam fir, white spruce, and white cedar.

The understory is multilayered and patchy. It is composed of shrubs and seedlings and saplings of the canopy trees. Some of the shrub species commonly present are fly honeysuckle, beaked hazel, leatherwood, mountain maple, chokecherry, and red-berried elder. The height and abundance of these shrubs varies with the degree of shading from canopy trees. In general, the shurbs are tallest beneath tree-fall canopy gaps.

The groundlayer is composed of a combination of northern and southern mesic herb species (i.e., those with distributions either mainly north or mainly south of the forest tension zone). The relatively few spring ephemerals present and the occurrence of club mosses in the groundlayer help differentiate Northern Hardwood Forest from Maple-Basswood Forest.

Northern Hardwood Forest occurs on loamy or sandy loam soils on fire-protected sites, especially on the rugged Sugar Hills Moraine and in the Lake Superior Highlands. In north-central Minnesota, Northern Hardwood Forest often occurs on sites with fine-textured subsurface layers that prevent or slow the downward movement of water and nutrients. Northern Hardwood Forest is a late-successional community with old-growth potential. Regeneration occurs primarily by gap-phase replacement so stands usually are uneven aged.

The Northern Hardwood Forest type includes most stands classified as Northern Hardwood-Conifer Forest in the 1983 community classification. Other stands previously classified as Northern Hardwood-Conifer Forest remain as Northern Hardwood-Conifer Forest in this classification or are included in the Red Maple Subtype of Oak Forest. There are two sections of Northern Hardwood Forest in Minnesota (Fig. 4), a Northern Section, occurring mainly north of the tension zone, and a Southeast Section, which occurs in southeastern Minnesota on steep north-facing slopes and bluffs. Northern Hardwood Forests in the Southeast Section contain such characteristically northern species as balsam fir, yellow birch, and American yew and often

Figure 2. The Southeast, Big Woods, Central, Northeast, and Northwest Sections of Oak Forest.

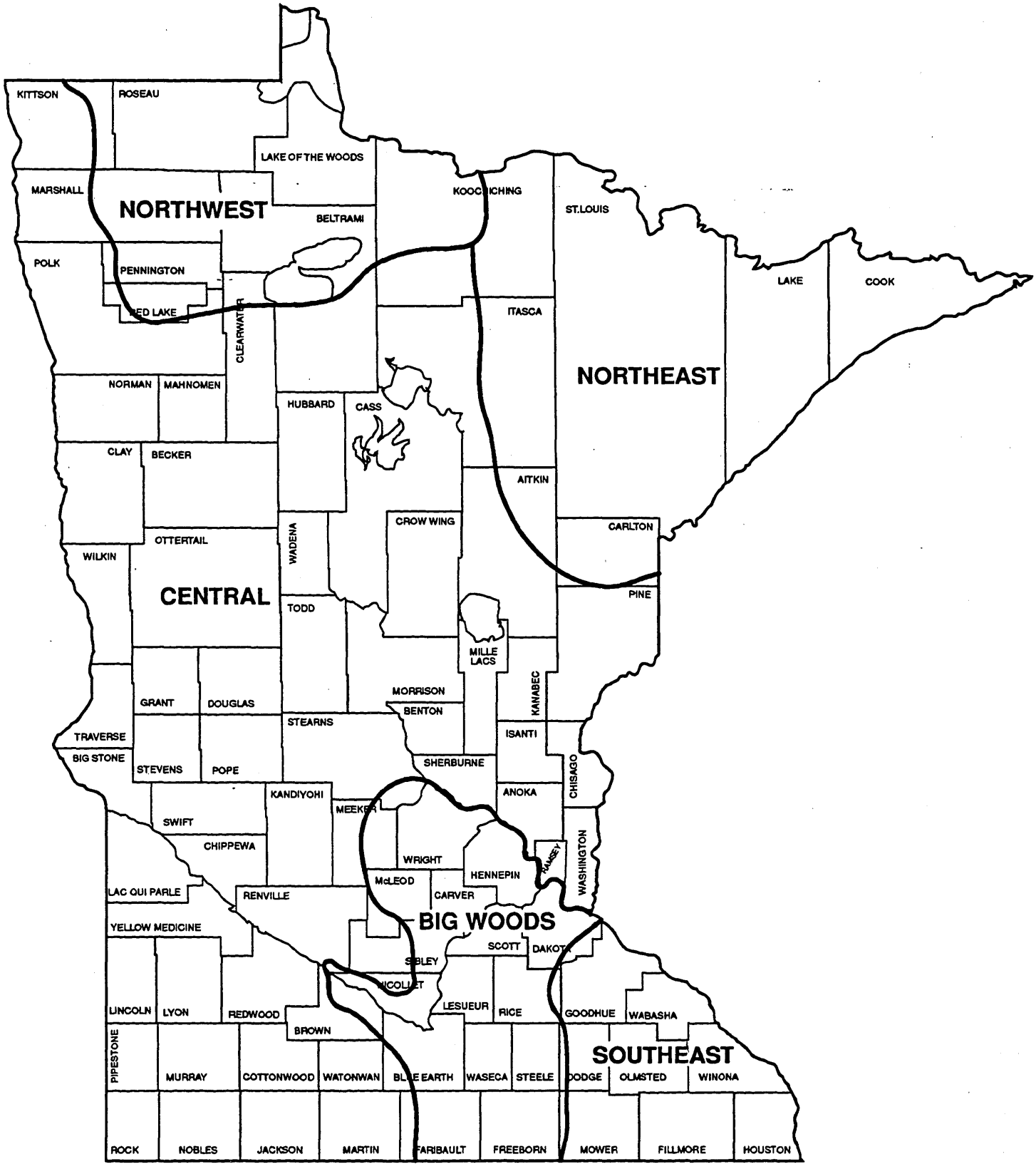


Figure 3. The Paleozoic Plateau in Southeastern Minnesota.

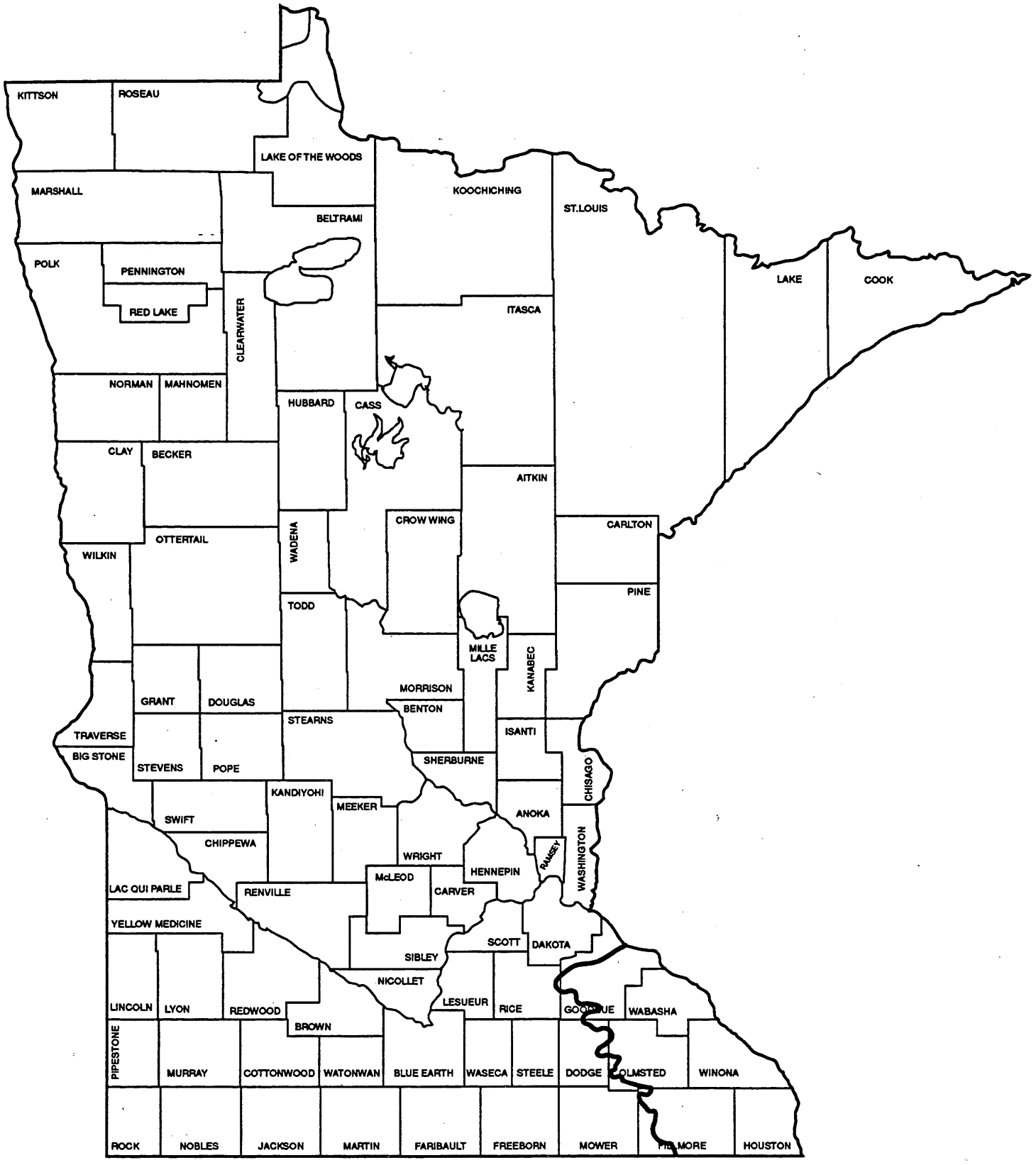
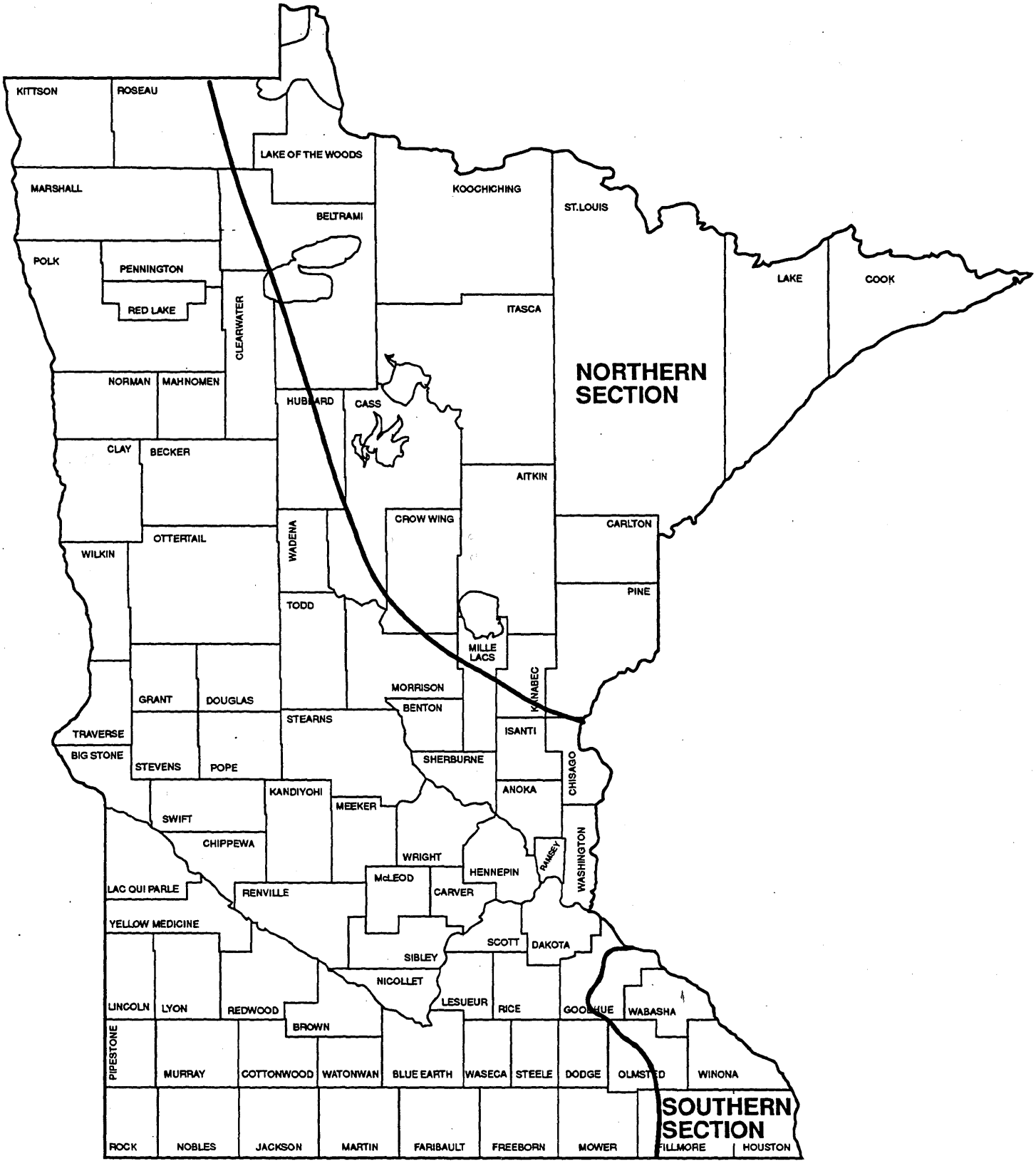


Figure 4. The Southeast and Northern Sections of Northern Hardwood Forest.



are associated with Moist Cliff communities.

Maple-Basswood Forest

Maple-Basswood Forest is a mesic community of the deciduous forest-woodland zone (Fig. 1), especially the portion from southeastern to west-central Minnesota. It also occurs occasionally in the conifer-hardwood forest zone and as isolated stands in the prarie zone on sites well protected from fire.

The tree canopy of Maple-Basswood Forests is dominated mostly by basswoods, sugar maples, and (formerly) American elms. Other mesic trees, such as slippery elms, northern red oaks, bur oaks, white ashes, and green ashes, are sometimes dominant locally. The canopy is very dense, with tall, straight, relatively narrow-crowned trees. The understory is multi-layered and patchy. It is composed of saplings and seedlings of the canopy species (especially sugar maple), along with American hornbeam, ironwood, bitternut hickory, pagoda dogwood, and leatherwood.

Because the tree canopy permits so little light to reach the forest floor during the summer, Maple-Basswood Forests have a suite of forb species that bloom, produce seeds, and die back in May and early June before tree leaves are fully developed. These species--the spring ephemerals and the winter annuals--include spring beauties (*Claytonia* spp.), Dutchman's breeches (*Dicentra cucullaria*), trout-lilies (*Erythronium* spp.), and cleavers (*Galium aparine*). Other herbs, such as the sedge *Carex pedunculata*, bottlebrush grass (*Hystrix patula*), and bearded short-husk (*Brachyelytrum erectum*), are commonly present in the groundlayer but usually not abundant.

Maple-Basswood Forest occurs only on protected sites, where catastrophic forest crown fires were rare historically. Across most of its range, the community develops most commonly on well-drained loamy soils that lack mottling or other evidence of water-table levels within the tree-rooting zone. In north-central Minnesota, Maple-Basswood Forests develop on soils with fine-textured subsurface layers that slow the downward movement of water and nutrients.

Maple-Basswood Forest is a late-successional community, tending to succeed Mixed Oak Forest (and other forest types) on mesic sites. It is self-perpetuating in the absence of catastrophic disturbance and climate change because the dominant tree species readily reproduce by gap-phase replacement. The very shade-tolerant sugar maple seedlings and saplings, especially, may exist in a suppressed state in the understory for many years until the death of a mature tree when one or a few grow rapidly into the canopy gap. Maple-Basswood Forests often develop into old-growth forests, because catastrophic disturbances are rare in the community and because the dominant tree species are long-lived (> 250 years). The trend in most stands of Maple-Basswood Forest is toward greater dominance by sugar maple.

Maple-Basswood Forest grades into Oak Forest where the frequency of fire increases in the landscape. It grades into Lowland Hardwood Forest in low areas where elms and ashes become

more abundant and where the water table is at least seasonally within the tree rooting zone. Conifers are absent or uncommon in most of the range of Maple-Basswood Forest, but grow with sugar maple, basswood, and other mesic species in northeastern and southeastern Minnesota. The mixed stands in northeastern Minnesota are classified as Northern Hardwood Forest. In southeastern Minnesota they are classified as White-Pine Hardwood forest.

Undisturbed stands of Maple-Basswood Forest are rare. The soils on which the forest grows are suitable for cultivation so much of the community has been cleared for cropland. Remaining stands have often been grazed or selectively cut for lumber or fuelwood. Heavy grazing causes compaction of the soils and the almost complete destruction of the understory, resulting in even-aged woodlots with large mature trees in the canopy, little reproduction, and few native shrubs and herbs. Selective logging of the less shade-tolerant species (northern red oak, white oak, bitternut hickory, and walnut) has been common since European settlement, and has hastened dominance by sugar maple and basswood in many stands. The composition of the community has also been altered throughout its range by Dutch elm disease, which has killed most of the mature elm trees, and in many stands by the loss of interior groundlayer species following forest fragmentation. Common buckthorn and Tartarian honeysuckle sometimes invade stands of Maple-Basswood Forest, but rarely attain the high densities they may have in Oak Forest. Maple-sugaring is one human activity associated with Maple-Basswood forests that appears to have little impact on the structure and composition of the community, as some of the best remaining tracts of Maple-Basswood Forest have long histories of maple sugar production.

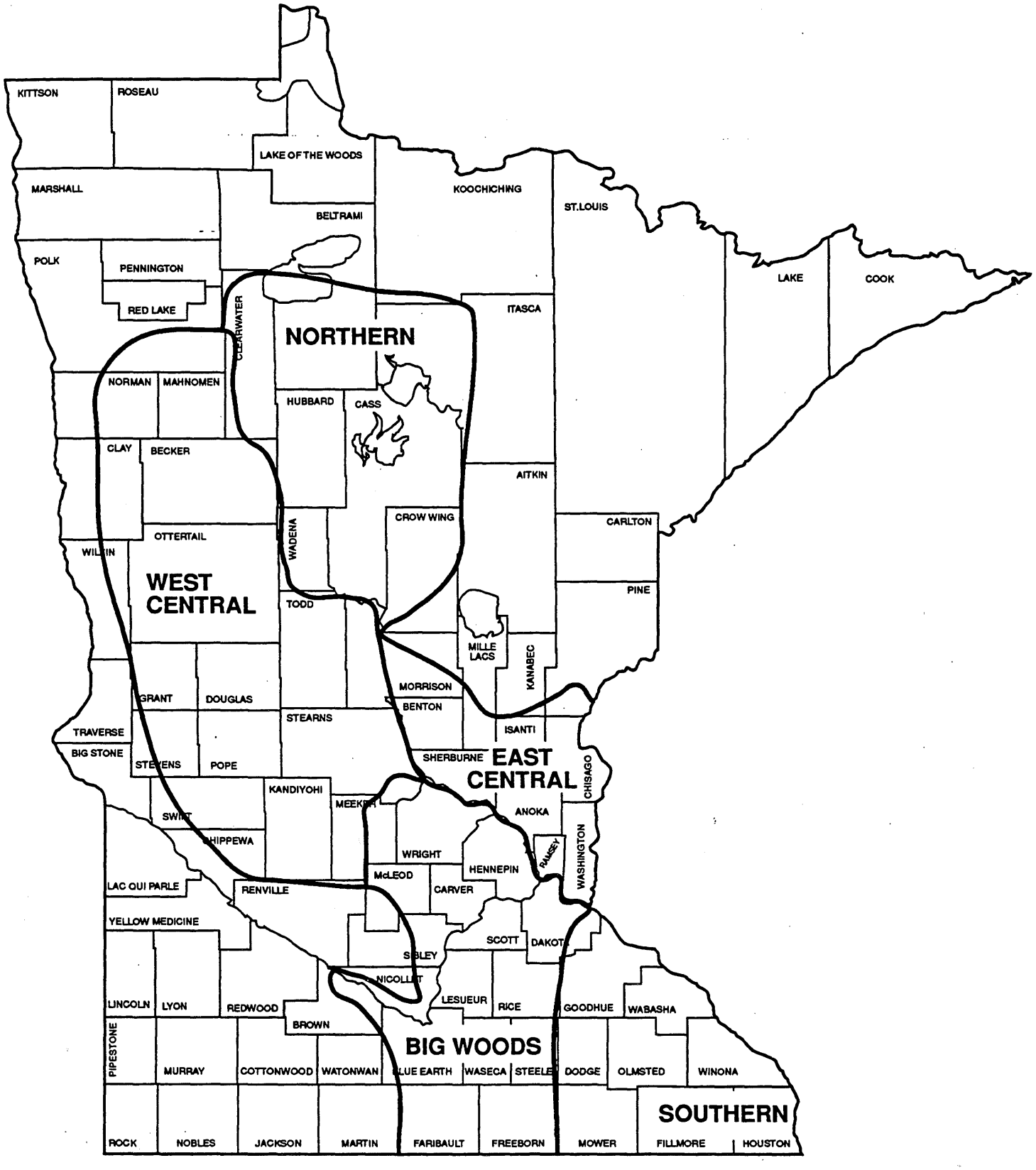
There are five recognized sections of Maple-Basswood Forest (Southeast, Big Woods, East Central, West Central, and Northern, Fig. 5). Subtypes likely will be recognized along a moisture gradient, following analysis of plot data.

Lowland Hardwood Forest

Lowland Hardwood Forest is a wet-mesic forest that is present throughout Minnesota. It is transitional between the terrestrial and palustrine systems, occurring on sites with seasonally high water tables (within the tree-rooting zone) but that do not flood regularly and that have mineral rather than peat soils. In accord with the poorly drained sites on which the Lowland Hardwood Forests occur, species tolerant of periodic soil saturation dominate the tree canopy. American elms and black ashes are common canopy dominants, but most stands are mixed, with slippery elms, rock elms, basswoods, bur oaks, hackberries, yellow birches, green ashes, black ashes, quaking aspens, balsam poplars, and paper birches as important species. The tall-shrub layer is usually discontinuous and is composed of a mixture of upland and lowland shrubs. The groundlayer is composed mostly of upland herbs that do not root to the water-table.

Lowland Hardwood Forest usually occurs in fire-protected areas, although even in unprotected areas the community burns infrequently because the woody vegetation is usually hydrated, especially in the spring. Lowland Hardwood Forest soils differ from Hardwood Swamp Forest soils by being mineral rather than peaty and from the mineral soils of other mesic upland forest types by being seasonally saturated (at depths greater than 0.5 meters).

Figure 5. The Southeast, Big Woods, East Central, West Central, and Northern Sections of Maple-Basswood Forest.



Lowland Hardwood Forest is often composed of late-successional species, but few stands in Minnesota have old canopy trees, presumably because of windthrow and infrequent episodes of killing floods. Lowland Hardwood Forest is topographically transitional between upland forests and forested peatlands and is best developed on flat terrain where such transition zones are broad (e.g., on river terraces above normal flood levels, on loamy ground moraine, and on drumlin fields).

Currently, there are no recognized subtypes or sections of Lowland Hardwood Forest. Following further field review, stands of Lowland Hardwood Forest may be reclassified as wet subtypes of Aspen-Birch or Aspen Forest, or dry subtypes of Hardwood Swamp Forest.

CONIFEROUS FOREST

Coniferous Forests are upland forest communities that occur mainly in the conifer-hardwood forest zone (Fig. 1) but also as small stands on the Paleozoic Plateau in southeastern Minnesota (Fig. 3) and in other parts of the deciduous forest-woodland zone. In general, Red Pine Forest and Jack Pine Forest occur on dry fire-prone sites, while forests composed of northern conifers (such as white spruce, balsam fir, white cedar, and black spruce) occur on mesic fire-protected sites. White Pine Forest occurs on sites ranging from wet to dry. In areas prone to fire or other disturbances, aspen and paper birch trees are common deciduous associates. In fire-protected areas, mesic northern hardwoods, such as sugar maple, basswood, and yellow birch, are common associates. The tall-shrub layer ranges from continuous to sparse, and varies locally in composition. The groundlayer is composed primarily of forest (rather than prairie) herbs, and often feathermosses. Herbs capable of growing in acid needle litter--such as clintonia (*Clintonia borealis*)), partridge-berry (*Mitchella repens*), and rose twisted-stalk (*Streptopus roseus*)--and herbs that commonly grow among feathermosses--such as wintergreen (*Gaultheria procumbens*), pyrola (*Pyrola* spp.), and cow-wheat (*Melampyrum linneare*)--are characteristic of Coniferous Forests.

The canopy trees of Coniferous Forests sometimes occur in mixtures, but often form relatively pure stands. The pines all require fire for stand regeneration, however the fire regime differs among the species (see below). White spruce and white cedar are sensitive to fire and occur in areas that rarely burn. Black spruce is adapted to fire as it has semi-serotinous cones. In extreme northern Minnesota trees growing in Black Spruce Bogs readily seed into adjacent burned uplands.

There are six Coniferous Forest community types in Minnesota, recognized primarily by dominant conifer species and associated fire-regimes:

a. canopy mostly pine ..... **b.**

b. canopy mostly white pine, often mixed with red pine; mesic hardwoods (Appendix 2) often present as minor components of the canopy; mesic hardwoods and balsam fir are common in the understory; habitat dry-mesic to mesic ..... ***White Pine Forest***

b. canopy mostly red pine or jack pine; oak and boreal hardwoods (Appendix 2) are occasional canopy associates; habitat dry to dry-mesic ..... **c.**

c. canopy <70% jack pine ..... ***Red Pine Forest***

c. canopy >70% jack pine ..... ***Jack Pine Forest***

a. canopy mostly white spruce, black spruce, white cedar, or balsam fir ..... **d.**

d. canopy mostly white spruce, black spruce, or balsam fir ..... **e.**

e. canopy mostly black spruce ..... ***Black Spruce - Feathermoss Forest***

e. canopy mostly white spruce or balsam fir ..... ***Spruce - Fir Forest***

d. canopy mostly white cedar ..... ***Upland White Cedar Forest***

White Pine Forest

White Pine Forest is a dry to dry-mesic coniferous forest present mainly in the conifer-hardwood forest zone and occasionally in the deciduous forest-woodland zone (Fig. 1). White pine trees dominate the canopy. They may be mixed with red pines and hardwoods, especially paper birches. Stands that originate following fire are often composed almost entirely of even-aged white pines. In the absence of periodic ground fires, hardwoods and other conifers increase in and dominate the understory. Balsam fir, white spruce, and white cedar are important in the understory in northeastern Minnesota, while southward sugar maple, northern red oak, red maple, and ironwood are important understory species. Stands of White Pine Forest usually have a moderately developed tall-shrub layer composed of bush honeysuckle, beaked hazel, mountain maple, round-leaved dogwood, and downy arrowwood. Prevalent groundlayer herbs include large-leaved aster (*Aster macrophyllus*), Canada mayflower (*Maianthemum canadense*), wild sarsaparilla (*Aralia nudicaulis*), bunchberry (*Cornus canadensis*), and common strawberry (*Fragaria virginiana*).

White Pine Forest occurs on moister sites--that typically burned less intensely in the past--than Red Pine Forest. White pine grows best on moderately well-drained deep loams and sandy loams. In northern Minnesota the best-developed White Pine Forests occur on mesic sites along lake margins and lower slopes. In north-central Minnesota, White Pine Forest occurs mostly on glacial till, while mixtures of white pine and red pine occur frequently on rugged moraines.

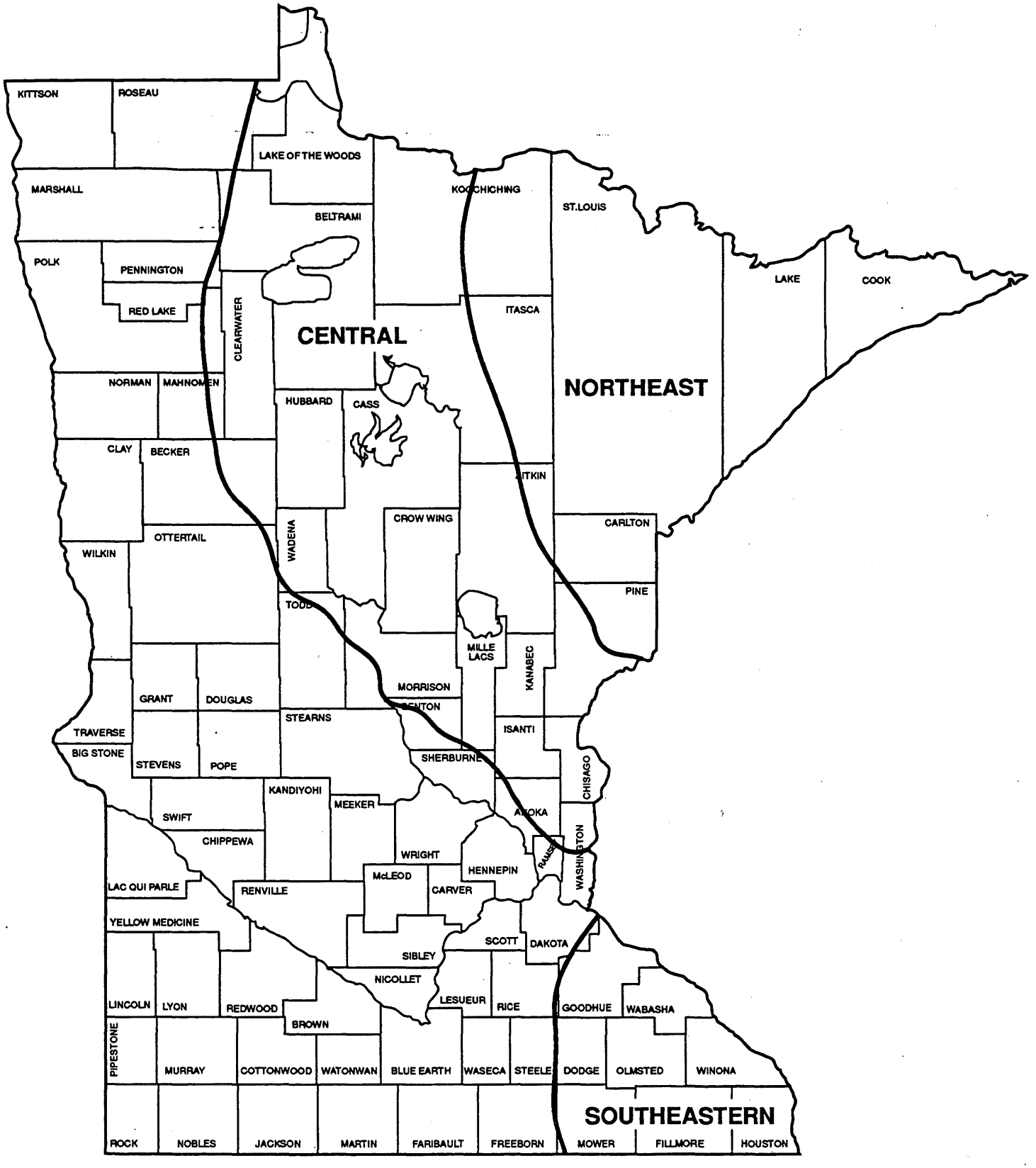
White Pine Forest is an early successional community, but is long lasting because white pine may live for several hundred years and can replace itself by gap-phase reproduction. White Pine Forest is a major old-growth forest type in Minnesota, although recruitment of white pine into the tree canopy is greatly reduced in parts of Minnesota (especially the northeast) where conditions are conducive to infestation by white pine blister rust. In northern Minnesota, White Pine Forest grades into Red Pine Forest on drier sites or where there is high fire frequency.

There are three recognized sections of White Pine Forest in Minnesota (Southeast, Central, and Northeast, Fig. 6).

Red Pine Forest

Red Pine Forest occurs in the conifer-hardwood forest zone (Fig. 1) on landforms where fires are common. These include areas of thin soil over bedrock, and coarse-textured ice-contact

Figure 6. The Southeast, Central, and Northeast Sections of White Pine Forest.



features such as ice-contact moraines, tunnel valleys, and kames. Red pine trees dominate the canopy, whcih also contains lesser amounts of jack pines on dry sites and white pines, white spruces, or balsam firs on mesic sites. Hardwoods, including paper birches, northern red oaks, red maples, and quaking aspens, sometimes form a subcanopy beneath the pine canopy. The tall-shrub layer is usually patchy, and is composed mostly of beaked hazel and juneberry. The groundlayer is composed of forest herbs and feathermosses. A continuous (>75%) cover of mosses (with *Pleurozium schreberi* being dominant) is common in shrub canopy openings.

Red Pine Forest is a fire-maintained community. Reconstructions of the fire regime using fire scars on red pine trees suggest that a combination of ground fires every 20 or so years and severe crown fires every 100 to 150 years were characteristic in the community before logging, settlement, and fire suppression. The ground fires kept the understory relatively open and exposed mineral soils for seed germination and continued regeneration of red pine. In the absence of fire, many of Minnesota's native red pine stands have become much brushier or are beginning to succeed to forests of mesic hardwoods and white pine. Except for some areas in the BWCAW, the Chippewa National Forest, and Itasca State Park, most of the native red pine groves have been converted by logging to other forest community types (especially Mixed Pine-Hardwood Forest) composed of the minor canopy species usually present in Red Pine Forests.

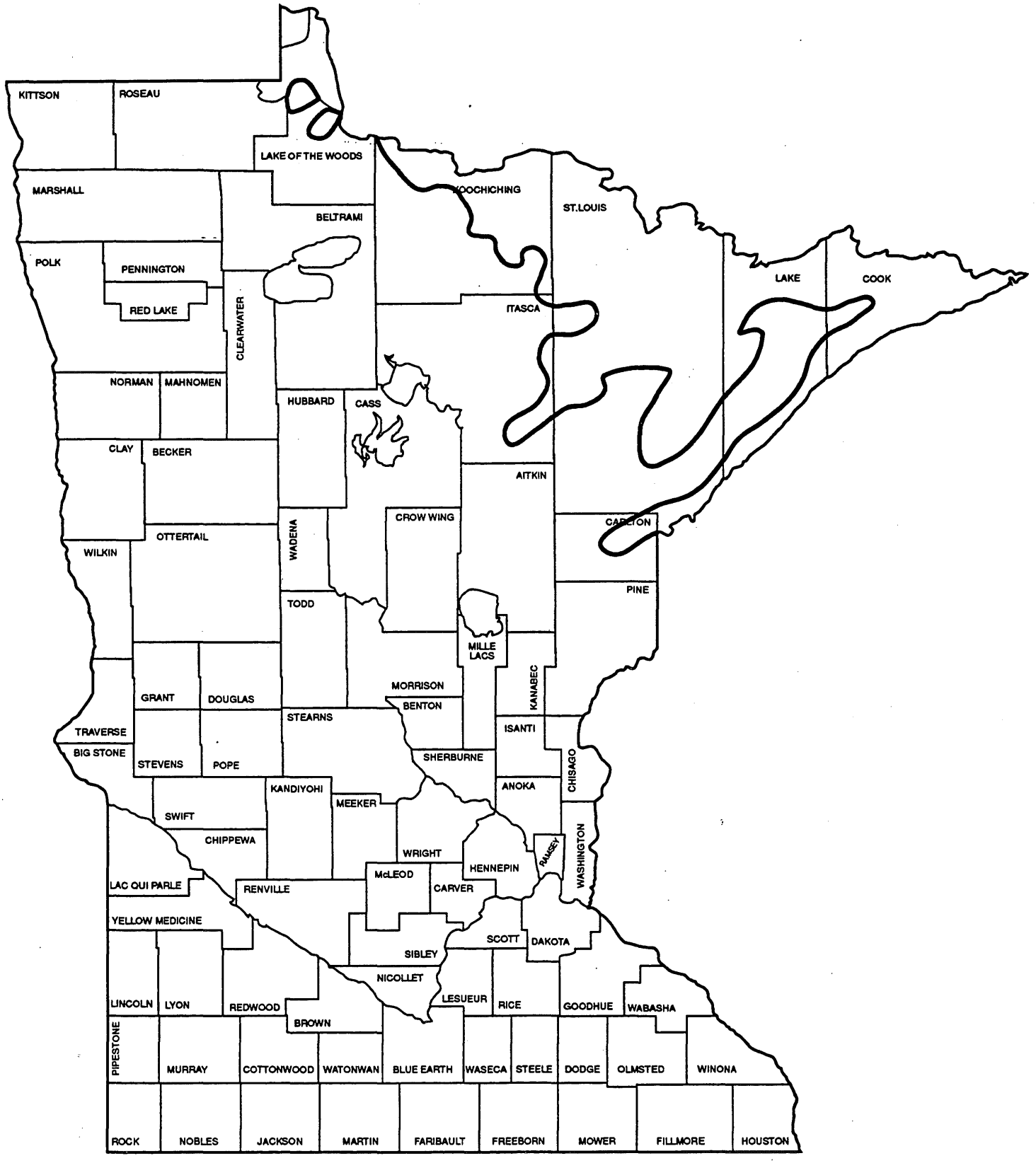
Floristic differences between stands of Red Pine Forest on the Canadian Shield and those on ice-contact features to the southwest may result in identification of Red Pine Forest subtypes. On dry-mesic sites, Red Pine Forest grades into Jack Pine Forest or Mixed Pine-Hardwood Forest. On mesic sites and sites with less frequent fire, Red Pine Forest grades into or succeeds to White Pine Forest, Boreal Hardwood-Coniferous Forest, or Northern Hardwood-Coniferous Forest.

Jack Pine Forest

Jack Pine Forest occurs on dry to dry-mesic, fire-prone sites in the conifer-hardwood forest zone (Fig. 1). On the dry sites, jack pine trees usually form almost pure stands. On the dry-mesic sites, oaks, balsam firs, black spruces, and red pines may be present with the jack pines as minor canopy codominants. The composition of the understory in the community is highly variable, with regional floristic differences between stands on the Canadian Shield of northeastern Minnesota (Fig. 7) and those on outwash plains in central Minnesota, and local differences (correlating with differences in soil organic matter) among stands on the outwash plains. Descriptions of the understory vegetation appear below, in descriptions of the subtypes of the community.

Jack Pine Forest is dependent on fire for regeneration. On the Canadian Shield, jack pines are of the closed-cone (serotinous) ecotype. Therefore the regeneration of the community usually occurs following intense forest fires that open the cones and burn away the forest litter, exposing mineral seedbeds. These stands are even aged, usually originating from a single hot fire. On outwash plains southwest of the Canadian Shield, jack pines are of the open-cone ecotype, with (at least some) cones opening up eventually with age or during hot weather. In

Figure 7. The Canadian Shield in Northeastern Minnesota.



these stands, most pine regeneration still occurs immediately following fires. If pine regeneration is poor following a fire, aspens and birches may seed into a site for several years along with jack pines, but eventually are supplanted by the jack pines. Stands of jack pines in the outwash plains often have cohorts of seedling- and sapling-sized jack pines that presumably are the offspring of parent trees that have survived minor disturbances (such as ground fires).

There are three recognized sections of Jack Pine Forest, the Central Section, the Northeast Section, and the Northwest Section (Fig. 8). The Northeast Section (which occurs primarily on the Canadian Shield) has three subtypes: Jack Pine-Oak, Jack Pine-Fir, and Jack Pine-Black Spruce. The Jack Pine-Oak Subtype occurs on rocky ridges. It is strongly dominated by jack pine, with an understory of northern red oak and red maple saplings and a groundlayer of drought-resistant forbs and grasses. This subtype often grades into Northern Coniferous Woodland. The Jack Pine-Fir Subtype occurs on relatively deep soils, often on north-facing slopes. It has saplings of balsam fir, paper birch, or black spruce in the understory, a well-developed shrub layer composed of beaked hazel, mountain maple, fly honeysuckle, and round-leaved dogwood, and a groundlayer of dry-mesic forest herbs (especially large-leaved aster (*Aster macrophyllus*)) and grasses. The Jack Pine-Black Spruce Subtype is dominated by jack pine, with black spruce trees, saplings, and seedlings present. It has a low-shrub layer of bush honeysuckle and blueberry, few forbs, and a cover of feathermosses. It often grades into Black Spruce-Feathermoss Forest.

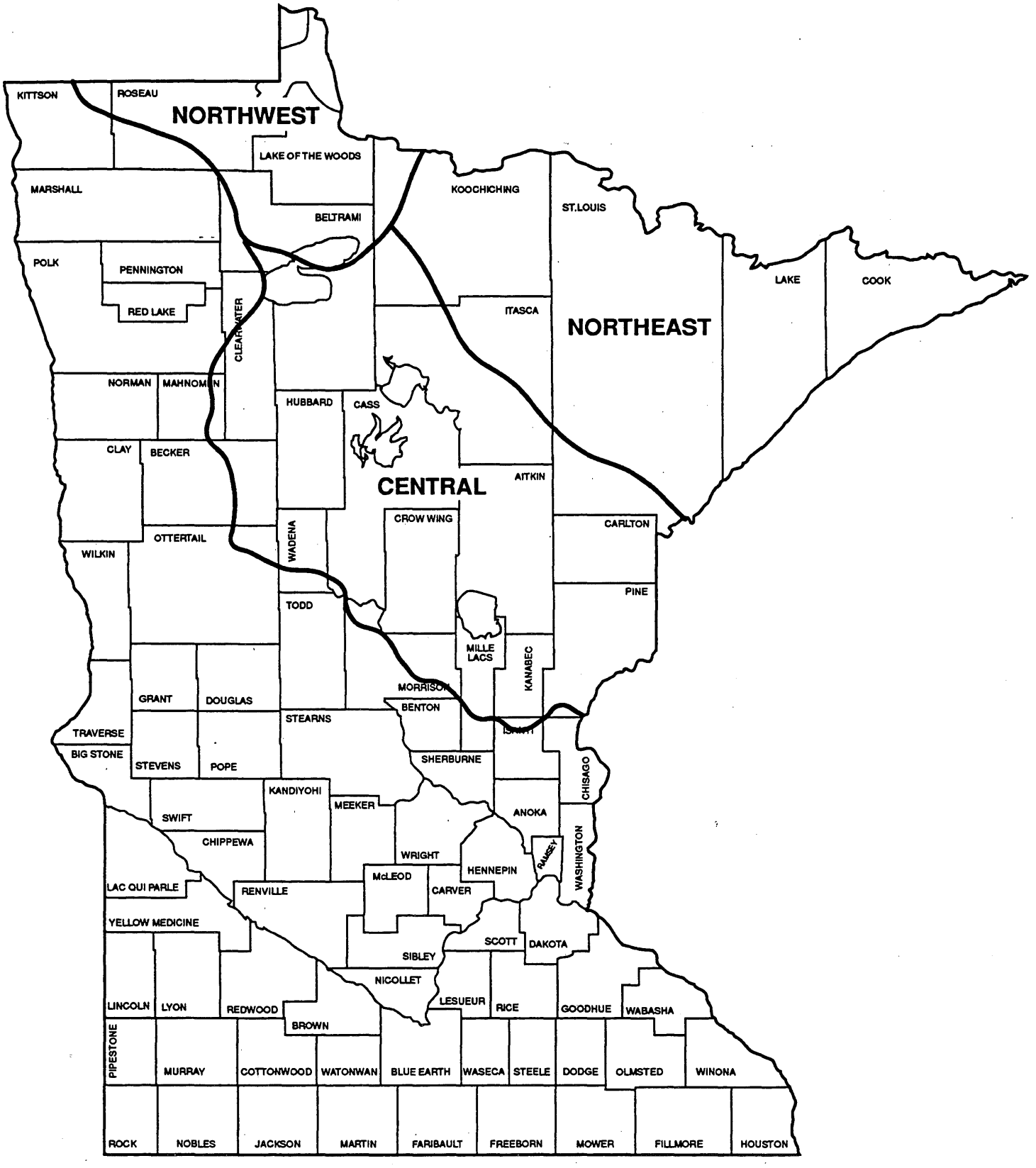
The Central Outwash Plain Section has two recognized subtypes. The most common is the Hazel Subtype, which has red pines and paper birches as common canopy or understory associates, and abundant tall shrubs including beaked hazel, juneberry, and downy arrowwood. The groundlayer is composed of forest species. Soils usually have greater than 2.5% organic matter. These stands grade into Red Pine forest. The less common subtype, the Blueberry Subtype, consists of nearly pure stands of jack pines with very few, if any, tall shrubs. The groundlayer is composed of feathermosses, ericaceous half-shrubs (especially blueberries), and prairie forbs and grasses. These open stands usually occur on soils with less than 2.5% organic matter. Structurally, they resemble Black Spruce-Feathermoss Forests and the Jack Pine-Black Spruce Subtype of the Northeast Section.

The Northwest Section is centered on the Beltrami Island Highland south of Lake of the Woods. Most stands occur on poor sandy soils on beach ridge-dune complexes, although there are some outlying stands on areas of wave-washed till in the Agassiz Lake Plain. On sandy sites the understory usually is open and depauperate and composed mainly of upland forest herbs, although stands on sites with fine sand soils or high water tables sometimes have brushy understories. Stands on areas of till have more diverse understories, with denser shrub layers and more species of mesic herbs than the stands on sandy soils. Occurrences of Jack Pine Forest in the Northwest Section may grade into Black Spruce Forests in adjacent low areas.

Black Spruce - Feather Moss Forest

Black Spruce-Feather Moss Forest occurs in the conifer-hardwood forest zone (Fig. 1) in

Figure 8. The Central, Northeast and Northwest Sections of Jack Pine Forest.



northeastern Minnesota, primarily in the BWCA and surrounding areas. It is the only upland forest community in which black spruces dominate the tree canopy. Jack pines are also sometimes present in the canopy, along with lesser amounts of balsam fir, quaking aspen, white spruce, paper birch, and other tree species. Although the understory in the community typically is open, clumps of black spruce and other tree saplings sometimes form a tall-shrub layer. The low-shrub layer and herb layer are depauperate and usually dominated by ericaceous species, although bunchberry (*Cornus canadensis*) is abundant on some sites. The moss layer is conspicuous, continuous, and dominated by feathermosses (e.g., *Pleurozium schreberi*). Black Spruce - Feathermoss Forest sometimes intergrades with Jack Pine Forest (Jack Pine - Black Spruce Subtype).

Spruce-Fir Forest

Spruce-Fir Forest is a mesic coniferous forest of the northern portion of the conifer-hardwood forest zone (Fig.1). The canopy is dominated by white spruce or balsam fir, or a combination of these species with black spruce. White spruce and balsam fir are shade-tolerant, late-successional species, but they often occur on landscapes were fire frequencies are high. White spruce and, especially, balsam fir are susceptible to periodic outbreaks of spruce budworm. Structurally, the understory of Spruce-Fir Forest is quite variable.

Spruce-Fir Forest grades into Boreal Hardwood-Conifer Forest where hardwoods increase in abundance, and into Upland White Cedar Forest on sites with richer, moister soils. Old-growth Spruce-Fir Forest may develop on sites protected from catastrophic disturbance. Where deer populations are low, some stands of Spruce-Fir Forest eventually succeed to Upland White Cedar Forest.

There are two recognized subtypes of Spruce-Fir Forest, a Fir-Birch subtype, and a White Spruce-Balsam Fir subtype. These subtypes were delimited primarily from plant associations described in the scientific literature. The Fir-Birch Subtype is dominated by balsam fir and paper birch, and often contains black spruce and white cedar, and small amounts of white spruce, quaking aspen, white pine and mountain ash. The White Spruce-Balsam Fir Subtype has a canopy dominated by white spruce, with lesser amounts of balsam fir. The tall-shrub layer in this subtype is moderately dense, and is composed of balsam fir saplings, mountain maples, and beaked hazels. Some stands may have a poorly developed shrub layer, and a groundlayer of feather mosses.

Upland White Cedar Forest

Upland White Cedar Forest is a mesic to wet-mesic coniferous forest of upland sites. It occurs almost exclusively in the conifer-hardwood forest zone (Fig. 1) (there are two known outlying stands in the Mississippi River Valley in extreme southeastern Minnesota). Within the conifer-hardwood forest zone, the community is most common in northeastern Minnesota, especially near the north shore of Lake Superior.

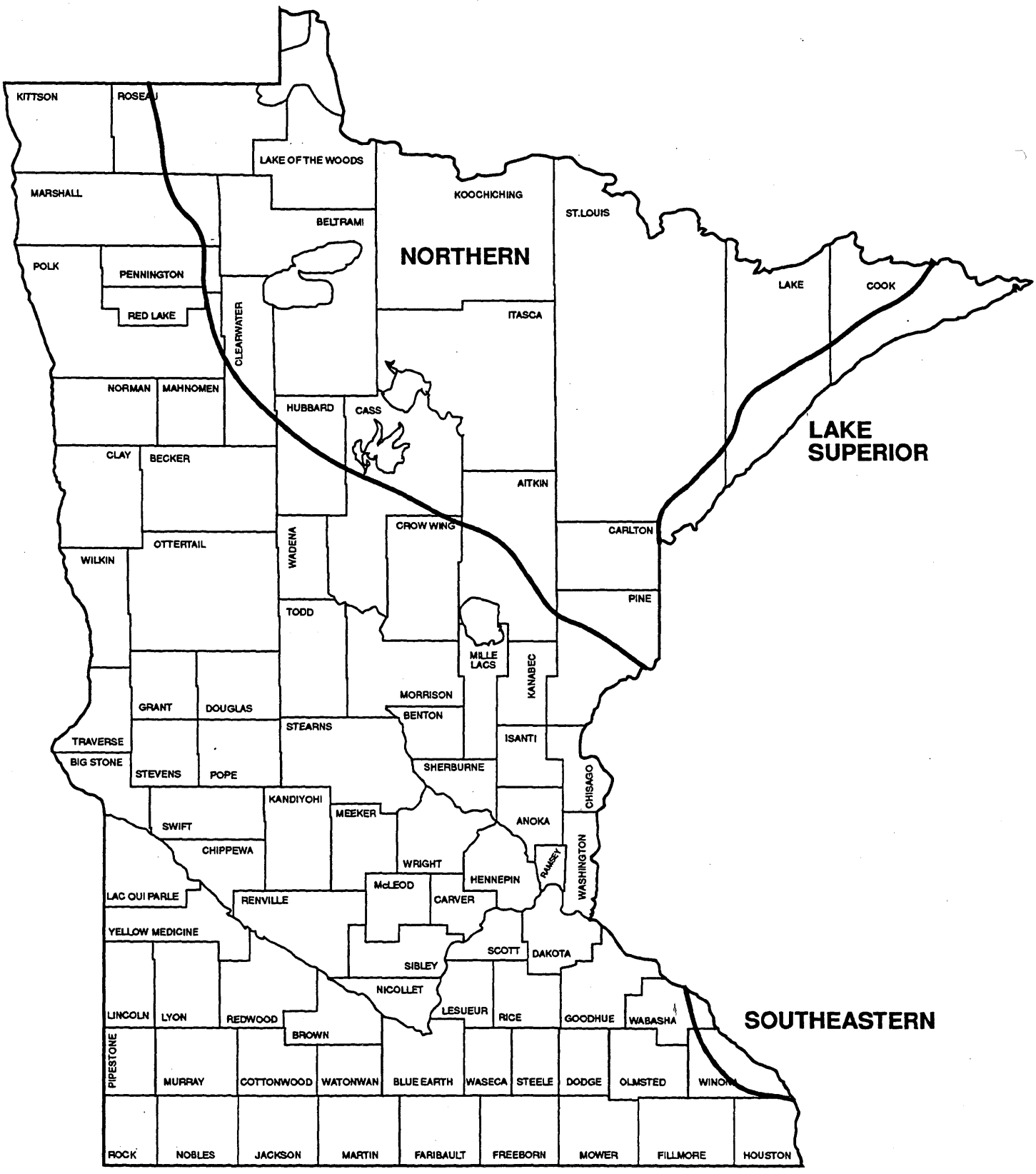
The canopy of Upland White Cedar Forest is dominated by white cedar, which may occur in extensive, nearly pure stands, in mixtures with other canopy species, or as small groves in a matrix of brushy forest. The most common subdominant canopy species are balsam fir, yellow birch, paper birch, white spruce, and black spruce. Older stands have many fallen logs and leaning trees.

Deciduous shrubs (especially mountain maple, with smaller amounts of speckled alder and beaked hazel) and conifer seedlings and saplings (spruce and especially balsam fir) dominate the understory of the community. The groundlayer contains a variety of species characteristic of mesic to wet-mesic sites; starflower (*Trientalis borealis*), wild sarsaparilla (*Aralia nudicaulis*), clintonia (*Clintonia borealis*), oak fern (*Gymnocarpium dryopteris*), large-leaved aster (*Aster macrophyllus*), bunchberry (*Cornus canadensis*), and dwarf blackberry (*Rubus pubescens*) are common. Three-flowered bedstraw (*Galium triflorum*) and naked bishop's-cap (*Mitella nuda*) are modal species in the community. In general, the understory and groundlayer of Upland White Cedar Forest are rich in species in stands on level, wet-mesic sites and less diverse on drier slopes.

Many of the existing Upland White Cedar Forests are over 100 years old and forests on some sites are well over 200 years old. These old-growth forests occur in fire-protected areas, typically on mineral soils. Upland White Cedar Forest occurs on diverse topographies, from very steep, well-drained slopes to gentle, wet-mesic slopes that grade into depressions containing White Cedar Swamp or other lowland types. Along the north shore of Lake Superior, Upland White Cedar Forest occurs downslope from Northern Hardwood Forest and upslope from several lowland conifer forest types. Soils in Upland White Cedar Forests tend to have relatively high levels of calcium. It appears that many of the existing stands of the community originated following catastrophic fires on sites where fire is usually rare. Browsing by deer can have a significant impact on white cedar reproduction; in areas with moderate to high deer populations, few white cedars reach the sapling size class or grow into the canopy. Where white cedar reproduction is poor, some occurrences of the community appear to be succeeding to Northern Hardwood Forest dominated by yellow birch, while others may succeed to Spruce-Fir Forest.

There are three recognized geographic sections of Upland White Cedar Forest, the Northern Section, the Lake Superior Section, and the Southeast Section (Fig. 9). Mesic and Wet-Mesic subtypes occur in the Northern and Lake Superior sections.

Figure 9. The Southeast, Northern, and Lake Superior Sections of Upland White Cedar Forest.



MIXED CONIFEROUS-DECIDUOUS FOREST

Mixed Coniferous-Deciduous Forests are upland forest communities made up of significant amounts of both coniferous trees and broad-leaved deciduous trees. They are most common in the conifer-hardwood forest zone but also occur in the deciduous forest-woodland zone (Fig. 1). The communities in this class occur on dry to wet-mesic sites, may be early successional or late successional, and originate following either natural catastrophic disturbance or clear-cutting. The logging and burning of Coniferous forests that came with European settlement caused widespread loss of pine seed sources and the subsequent conversion of large acreages of Coniferous Forests to Mixed Coniferous-Deciduous Forests and Deciduous Forests.

There are four Mixed Coniferous-Deciduous Forest community types, which are delimited by dominant canopy species. The abundance and distributions of these dominant canopy species are determined mainly by landform, soils, and the frequency and nature of disturbance at a site.

a. canopy a mixture of jack pine, red pine, or white pine with oak, aspen, or paper birch; habitat dry to dry-mesic; early to mid-successional community; dominant canopy trees usually even-aged; evidence of fire or other disturbances common ..... **b.**

> **b.** conifers predominantly jack pine, red pine, or a mixture of the two; a community primarily of the conifer-hardwood forest zone (Fig. 1) ..... ***Mixed Pine-Hardwood Forest***
>
> **b.** conifers predominantly white pine; a community primarily of the deciduous forest-woodland zone/conifer-hardwood forest zone transition, or of the Paleozoic Plateau of southeastern Minnesota (Fig. 3) ..... ***White Pine-Hardwood Forest***

a. canopy a mixture of white pine, balsam fir, white spruce, or white cedar with hardwoods; habitat mesic to wet-mesic; early to late-successional community; dominant canopy trees usually uneven-aged, although boreal hardwood species in canopy may be even-aged; evidence of fire or disturbances other than windthrow absent or restricted to the oldest individual trees ..... **c.**

> **c.** hardwood component composed of boreal species such as aspen and paper birch; red maple is often a significant component, especially in the subcanopy; community present only to the conifer-hardwood forest zone (Fig. 1) ... ***Boreal Hardwood-Conifer Forest***
>
> **c.** hardwood component dominated by northern, long-lived, shade-tolerant species, especially sugar maple and yellow birch; basswood, northern red oak, green ash, black ash, American elm, and slippery elm also sometimes present in the canopy; community of the conifer-hardwood forest zone (Fig. 1) and the Paleozoic Plateau (Fig. 3) ..... ***Northern Hardwood-Conifer Forest***

Mixed Pine-Hardwood Forest

Mixed Pine-Hardwood Forest is a dry to dry-mesic forest of the conifer-hardwood forest and deciduous forest-woodland zones (Fig. 1). Red pines or jack pines, or both, are important in the canopy, along with aspens, paper birches, and oaks. Mixed Pine-Hardwood Forest generally occurs on sites with coarse-textured soils where pre-European settlement fires were frequent and intense. Mixed Pine-Hardwood Forest is most common on sandy outwash plains, but also occurs on morainal topography.

White Pine-Hardwood Forest

White Pine-Hardwood Forest occurs on dry to dry-mesic sites in the deciduous forest-woodland zone (Fig. 1). White pines are the only conifers in the canopy and often form a supercanopy above the hardwood canopy. Northern red oak is an important canopy species along with sugar maple, white oak, and, in southeastern Minnesota, black oak and white ash. Eastern red cedars are often abundant in disturbed (especially by grazing) southeastern forests. On the Anoka Sandplain and in the St. Croix River Valley, the most common deciduous species in the canopy are northern pin oak and big-toothed aspen. The understory of the community commonly contains species that are common also in dry-mesic Maple-Basswood Forests and mesic Oak Forests.

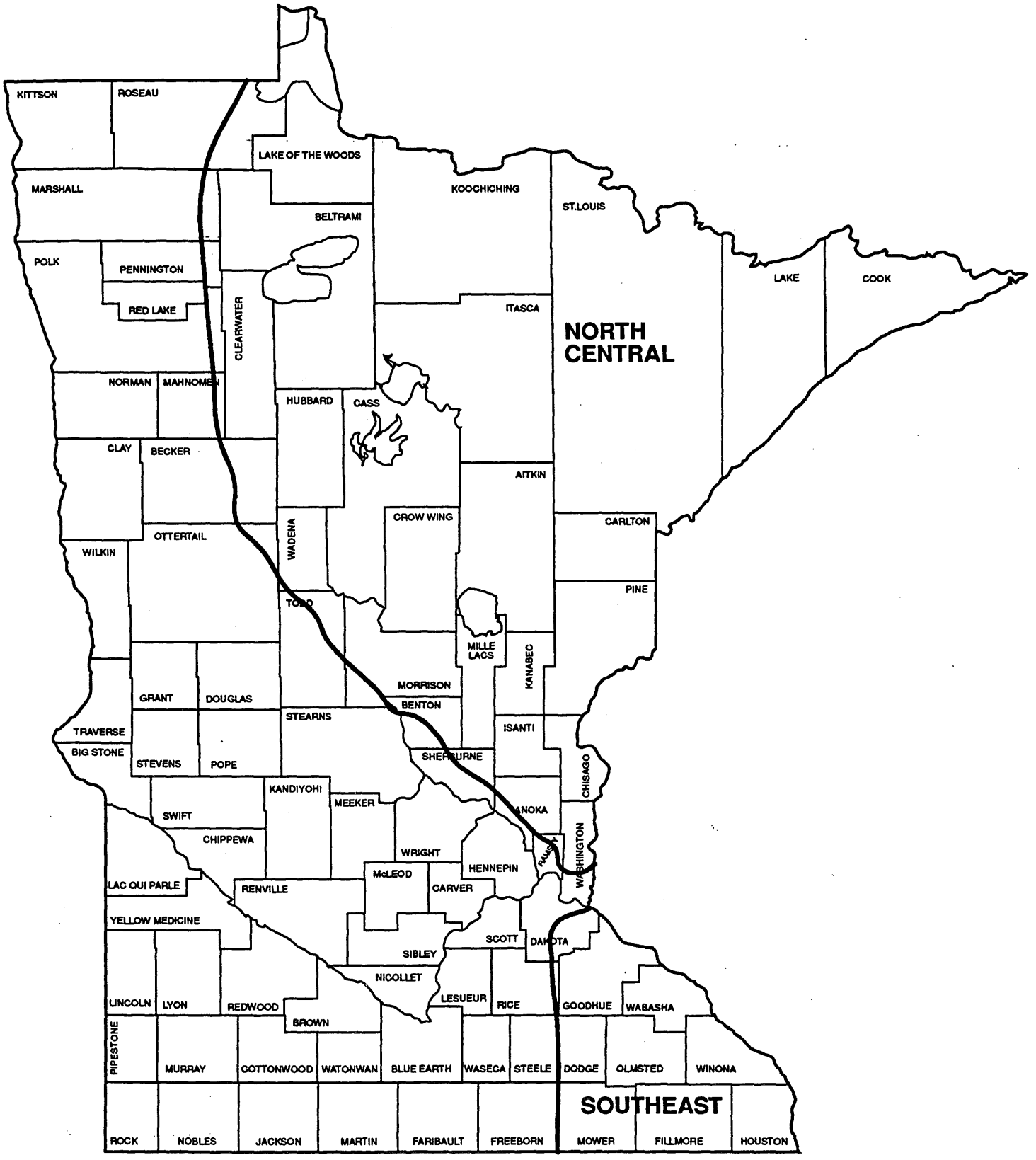
White Pine-Hardwood Forest occurs on sites with well-drained to excessively well-drained sandy loams or coarser soils, and on slopes. It is generally a mid-successional community, with some potential for developing into old-growth forest because of the longevity of white pines, the oaks, and sugar maples. In the southern and western part of its range, White Pine-Hardwood forest often grades into Maple-Basswood Forest on dry-mesic sites, and into Mixed Oak Forest on dry sites. In the northern part of its range the community commonly grades into White Pine Forest.

There are two recognized sections of White Pine-Hardwood Forest, the Southeast Section and the North-Central Section (Fig. 10). The Southeast Section has two subtypes, the Dry Subtype and the Mesic Subtype.

Boreal Hardwood-Conifer Forest

Boreal Hardwood-Conifer Forest occurs in the conifer-hardwood forest zone of northern Minnesota (Fig. 1). The tree canopy is dominated by a mixture of early successional hardwoods (primarily quaking aspen, paper birch, and red maple) and conifers (balsam fir, white spruce, white pine, jack pine, white cedar and black spruce). The proportions of these canopy trees vary significantly, in accordance with variation in soil depth and texture. Balsam fir, however, is important in the understory of Boreal Hardwood-Conifer Forests throughout the range of the community.

Figure 10. The Southeast and North Central Sections of White Pine-Hardwood Forest.



Mountain maple and beaked hazel are important species in the tall-shrub layer, which tends to be moderately dense. The low-shrub layer is not usually well-developed. Balsam fir dominates the seedling layer, but seedlings of other conifers and red maple are also sometimes important. The herb layer reflects the community's close affinity to Aspen-Birch Forest and Spruce-Fir Forest. Large-leaved aster (*Aster macrophyllus*) is the most important herbaceous species in the community, except in northwestern Minnesota, where it is replaced by Lindley's aster (*Aster ciliolatus*). Canada mayflower (*Maianthemum canadense*), clintonia (*Clintonia borealis*), bunchberry (*Cornus canadensis*), and wild sarsaparilla (*Aralia nudicaulis*) are common in the community throughout its range. Relatively high frequencies of twin-flower (*Linnaea borealis*) and starflower (*Trientalis borealis*) distinguish Boreal Hardwood-Conifer Forests from Aspen-Birch Forests.

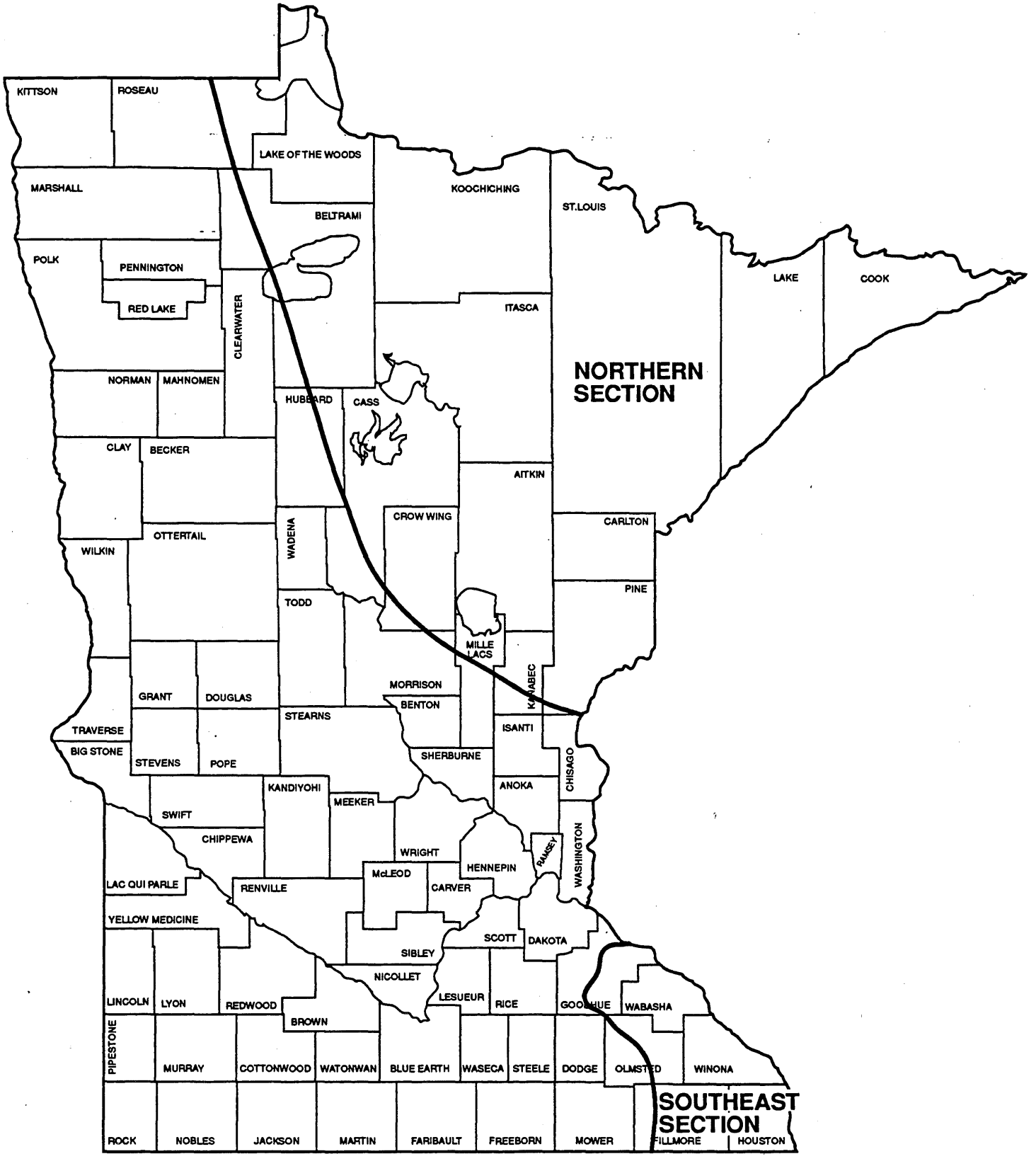
Boreal Hardwood-Conifer Forest is an early to mid-successional community that develops following forest fires or logging. If undisturbed, it tends to succeed to Spruce-Fir Forest or Upland White Cedar Forest. Boreal Hardwood-Conifer forest grades into Mixed Pine-Hardwood Forest on more xeric sites, into Aspen-Birch Forest where quaking aspens and paper birches become abundant, into Upland White Cedar where white cedars become more abundant, and into Northern Hardwood-Conifer Forest where sugar maples, basswoods and yellow birches become become more abundant.

Northern Hardwood - Conifer Forest

Northern Hardwood-Conifer Forest is a mesic forest of the conifer-hardwood forest zone (Fig. 1). The canopy is dominated by sugar maples or yellow birches, or both, along with whites pine, white spruces, white cedars, and balsam firs. Northern Hardwood-Conifer Forest occurs on moist sites but also occasionally on dry-mesic sites. The community is similar to Northern Hardwood Forest, but has a greater proportion of coniferous trees in its canopy. Northern Hardwood-Conifer Forest is a late- to mid-successional community, and is an important old-growth type. It commonly grades into Northern Hardwood Forest and Upland White Cedar Forest along the north shore of Lake Superior in northeastern Minnesota.

There are two sections of Northern Hardwood-Conifer Forest, a Southeast Section and a Northern Section (Fig. 11). In southeastern Minnesota, Northern Hardwood - Conifer Forest occurs on the Paleozoic Plateau (Fig. 3), typically as small stands on steep north-facing slopes. One subtype is present in the Northern Section of Northern Hardwood - Conifer Forest, the Yellow Birch-White Cedar Subtype, which develops on mesic to wet-mesic sites and has a canopy dominated by yellow birches and white cedars.

Figure 11. The Southeast and Northern Sections of Northern Hardwood-Conifer Forest.



DECIDUOUS WOODLAND

Deciduous Woodlands are communities of the deciduous forest-woodland zone (Fig. 1), composed primarily of oak or aspen trees (or both) and brush, especially hazelnut and gray-bark dogwood. Deciduous Woodlands have patchy, interrupted tree canopies, much like Deciduous Savannas. However, woodlands differ from savannas in that the trees are set in a matrix of brush with, at most, widely scattered prairie openings. (In savannas, the understory vegetation is composed of prairie grasses and forbs.)

In the past, woodlands probably were maintained by a combination of periodic fires, grazing by native herbivores, and intensive use of openings by Native Americans. Fine-scale landscape features that favored tree growth in prairie regions (e.g., rough topography, heavy soils) or that promoted openings in forested regions (e.g., steep slopes, south to west aspects, sandy soils) contributed to the origination and maintenance of Deciduous Woodland. These patterns of openings and wooded areas are apparent only over large areas of the landscape; therefore, woodlands now occur mainly in the more remote areas of Minnesota, where the landscape is relatively unfragmented and large areas of native vegetation remain.

Presently, communities that resemble native woodland are fairly common in Minnesota. However, most of these are disturbance communities that formed recently from the grazing or selective logging of deciduous forests. Many other apparently natural woodlands are savannas in which the prairie understory was replaced by brush following the onset of fire suppression in Minnesota.

There are two recognized types of Deciduous Woodland. These include some of the areas of vegetation described as oak barrens and openings by the early land surveyors, and areas described as scatterings of aspen timber.

a. tree cover >70% aspen; habitat dry to wet-mesic; terrain typically level to gently rolling ..... ***Aspen Woodland***

a. tree cover <70% aspen; canopy composed of any mixture of oak, green ash, and basswood, with or without aspen; habitat dry to mesic; terrain variable ..... ***Oak Woodland -Brushland***

Aspen Woodland

Aspen Woodland occurs primarily in the deciduous forest-woodland zone, with scattered groves in the prairie zone (Fig. 1). Quaking aspen is the dominant canopy species in the community across most of its range. In north-central Minnesota, however, big-toothed aspens occasionally dominate the canopy, and in the northwest, balsam poplars sometimes dominate low, moist areas. Bur oaks and green ashes are common associates throughout the community's range. Stands of Aspen Woodland have either dense canopies of even-aged immature trees,

irregular canopies of young and old trees, or tall, even canopies of mature trees.

The woody understory in the community is well-developed, with 40-90% cover. The understory may contain plants, including tree species, of several different height classes or it may have a well-defined shrub layer. On drier sites, hazelnut, gray-bark dogwood, chokecherry, downy arrowwood, *Rosa* spp., and *Rubus* spp. are common understory shrubs. On wetter sites, the common understory shrubs are red-osier dogwood, gray-bark dogwood, pussy willow, Bebb's willow, bog birch, and meadow sweet. These species are particularly characteristic in Aspen Woodlands in northwestern Minnesota that originated following the invasion of areas of wet-mesic Upland Prairie or Wet Meadow by aspen.

Aspen Woodland is a short-lived, early successional community intermediate between Upland Prairie (including Brush-Prairie) and Aspen or Oak Forests. Before European settlement, the distribution of Aspen Woodland in the prairie zone was determined by fire, with the community occurring in areas where fires were less frequent and intense than in open prairie areas. In the deciduous forest-woodland zone, Aspen Woodland probably was maintained by fire and occurred in association with Oak Forest, Aspen Forest, and some pine forests. Aspen Woodland has become more abundant in northwestern Minnesota because of fire suppression and perhaps wetland draining. Communities that originate following logging in the deciduous forest-woodland and conifer-hardwood forest zones often resemble Aspen Woodland but are not considered true Aspen Woodlands in this classification. When Aspen Woodland occurs with other related community types, such as Brush-Prairie and Aspen Openings, it tends to occur as narrow ecotonal bands between the other types or as small inclusions, and may be ignored in mapping.

There are insufficient data to delimit sections or subtypes of Aspen Woodland at this time. However, upland and lowland subtypes may be warranted, and a geographic section centered on the aspen parkland of northwestern Minnesota has been proposed. Further evaluation is necessary.

Oak Woodland - Brushland

Oak Woodland-Brushland occurs on dry to mesic sites throughout the deciduous forest-woodland zone and locally in the prairie zone near the ecotone between the prairie zone and the deciduous forest-woodland zone (Fig. 1). Oak Woodland is floristically and structurally intermediate between Oak Savanna and Oak Forest, with a patchy tree canopy and an understory dominated by shrubs and tree saplings.

The principal species in the tree canopy are bur oak, northern pin oak, white oak, and northern red oak. Aspens may form up to 70% of the tree canopy cover. The brush layer ranges in density from sparse (with 10-30% cover), to an impenetrable thicket. It is often especially dense in openings between clumps or groves of trees. Most of the floristic diversity in the community exists in the brush layer, which most commonly is composed of blackberries, raspberries, gooseberries, dogwoods, cherries, hazelnuts, prickly ashes, and sprouts of oak and

quaking aspen. Prairie vegetation, if present, occurs only in small openings in the tree or shrub canopy. Except in these scattered prairie openings, the herbaceous layer is sparse and floristically poor. It is usually composed of woodland species capable of surviving in the dense shade beneath the brush layer.

Oak Woodland-Brushland is a fire-maintained community. It is most common on rich sites where trees and shrubs grow well but where recurrent fires prevent the formation of true forest. Historically, Oak Woodland-Brushland was probably one of the most extensive community types in Minnesota, comprising much of the vegetation described as oak barrens, brushland, and thickets by the early surveyors. The fires that maintained Oak Woodland-Brushland usually started on nearby prairies. Following the conversion of these prairies to agricultural land, Oak Woodland-Brushland burned less frequently and rapidly succeeded to Oak Forest. Oak Woodland-Brushland is defined broadly enough here to include also communities in which the predominant cover is oak brush or oak-aspen brush (that originated following fire or limited human disturbance) instead of a well-developed tree canopy. There are four geographic sections of Oak Woodland-Brushland in Minnesota (Fig. 12). These sections may be modified in the future as more information becomes available.

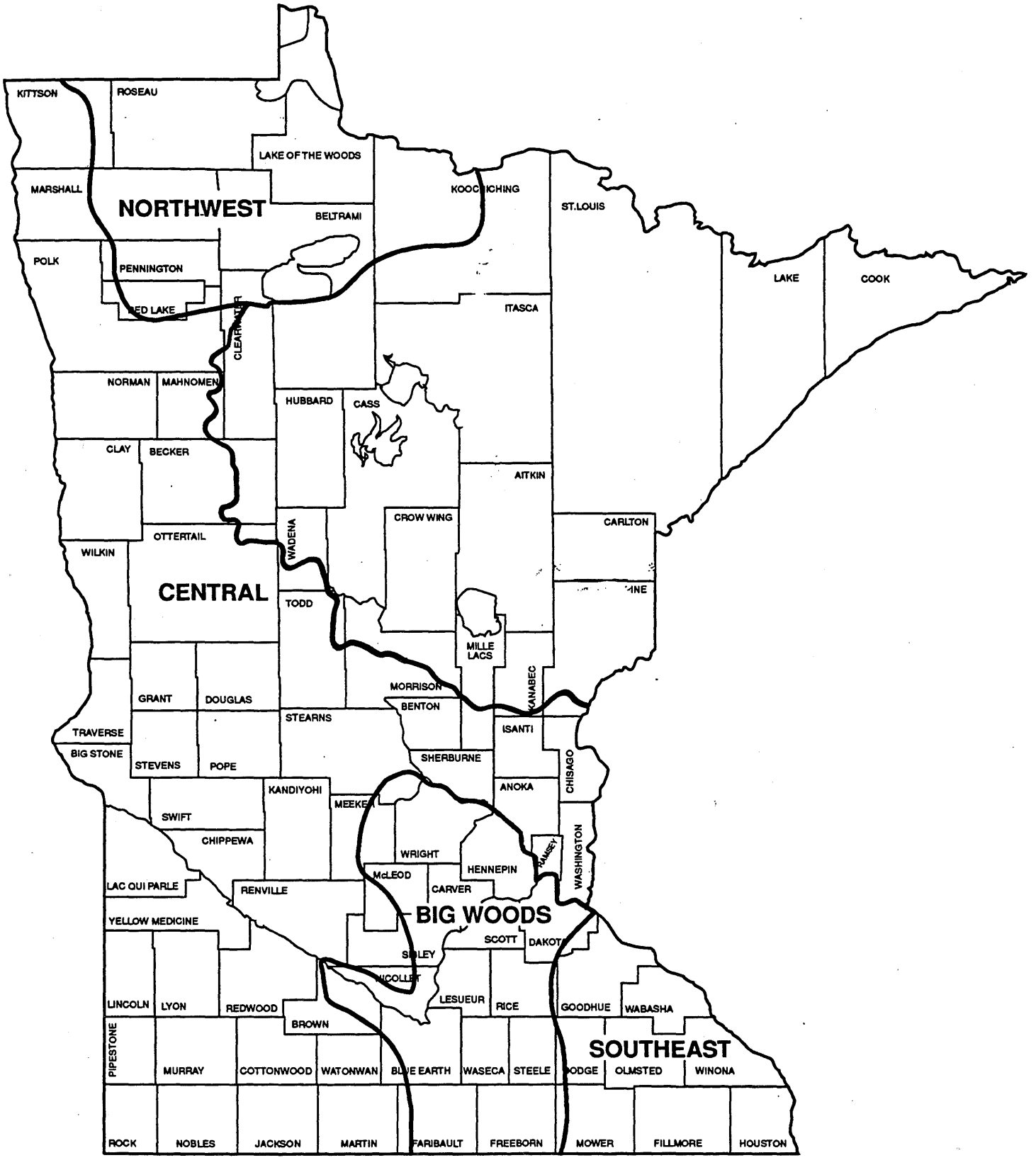
In the Southeast Section, Oak Woodland-Brushland is present on southwest-facing slopes on the blufflands and on outwash terraces of the Mississippi River and its tributaries. It generally occurs on more gentle slopes than Bluff Prairie or on lower slopes below Bluff Prairies. Bur oaks are common canopy dominants and northern red oaks are common associates. Northern pin oaks, basswoods, and black cherries may also occur in the canopy. White oaks are rare and aspens are absent. Chokecherries are common in the shrub layer, with shrub cover averaging 30-50%. On droughty sites with thin soils or steep slopes these woodlands may persist even in the absence of fire.

In the Big Woods Section, woodland dominated by white oak is present in areas with coarse-textured soils, such as on kames or eskers, or in areas prone to occasional fires. Natural woodlands are now extremely rare in this section because of logging, grazing, and fire suppression.

In the Central Section, Oak Woodland-Brushland historically occurred where there were firebreaks (such as on rough dune topography or on steep terrace slopes of the Mississippi River) in fire-prone regions. The dominant canopy species are either bur oak or northern pin oak; aspen are often present. Hazelnuts, chokecherries, gray-bark dogwoods, and *Rubus* spp. are common to abundant in the understory. Woodlands present in dune areas with nutrient-poor, droughty soils appear to persist for long periods even in the absence of fire.

In the Northwest Section, Oak Woodland-Brushland occurs on dry to dry-mesic sites on hilly moraines and glacial lake beach ridges. In the extreme northwest, the only oak species present is bur oak and the trees are often gnarly and relatively short. Aspens (either quaking aspens or balsam poplars or both) are always present. Southward, in Polk County, green ashes are occasionally present in the canopy. Hazelnuts, chokecherries, gray-bark dogwoods, *Viburnum* spp., *Rosa* spp., and *Rubus* spp. are common shrubs.

Figure 12. The Southeast, Big Woods, Central, and Northwest Sections of Oak Woodland-Brushland.



DECIDUOUS SAVANNA

Deciduous Savannas are communities of the prairie zone/deciduous forest-woodland zone transition. They are composed primarily of oak trees or aspen trees, or both, with a groundlayer of prairie species. The oak and aspen trees are distributed either evenly or in scattered groves smaller than 1 to 2 hectares (whether the trees are described as evenly distributed or clumped is of course dependent on the scale at which the vegetation is considered). The oaks have two growth forms: large-diameter open-grown trees, often with fire scars on their trunks, and clusters of spindly sprouts growing from a common root collar. The aspens usually occur in clumps, most often with all of the tree stems in a clump originating from the same root system. Brush is either absent from Deciduous Savanna communities or locally abundant, while prairie openings are always present.

Deciduous Savanna communities are early successional communities. Historically, they appear to have been maintained by fire and by grazing bison and elk. With fire suppression and the destruction of bison and elk herds, many tracts of savanna have succeeded to woodland or forest. Recently grazed woodlots may superficially resemble native savanna (especially in aerial photographs) but degraded forest or woodland lack the native prairie understory always present in ungrazed savannas.

There are three recognized types of Deciduous Savanna. These include community types historically described as oak savanna, oak openings, and oak barrens, or as aspen groves in open prairie.

a. trees most commonly bur oak, occasionally pin oak or (in southeastern Minnesota) black oak; often with some aspen or hazelnut brush; habitat dry to dry-mesic; herbaceous vegetation in open areas composed mostly of prairie species (Appendix 3) ..... OAK SAVANNA .... **b.**

> **b.** level to rolling topography, slopes generally $<10\%$; habitat mesic; soils with mollic epipedon; texture clay loam to loamy fine sand; somewhat poorly to somewhat excessively drained; herbaceous vegetation in opening areas similar to that of Mesic Prairie ..... ***Mesic Oak Savanna***
>
> **b.** undulating to rough topography, slopes of various degrees; habitat dry to dry-mesic; soils with or without mollic epipedon; texture loamy sand to sand on gentle slopes, or any texture on steep slopes; well drained to excessively drained ..... ***Dry Oak Savanna***

a. trees most commonly quaking aspen with various amounts of balsam poplar on wetter sites and bur oak on drier sites; habitat dry to wet-mesic, often with locally wet areas; herbaceous vegetation in open areas similar to that of Upland Brush-Prairie or Wet Brush-Prairie ..... ***Aspen Openings***

Mesic Oak Savanna

Mesic Oak Savanna is very rare in Minnesota. Historically, it occurred in the prairie and deciduous forest-woodland zones (Fig. 1). The characteristic trees were bur oaks and to a lesser extent northern pin oaks. Northward, quaking aspens were probably common in moister parts of Mesic Oak Savannas. The stature and spacing of the oaks in the community probably varied considerably, primarily with differences in fire history, which were themselves related to differences in soils, landforms, and climate. Grubs and small, gnarly, open-grown trees were probably most common. The distribution of trees ranged from evenly spaced to strongly clumped. Shrub cover, likewise, was probably quite variable. The shrub layer included chokecherries (*Prunus virginiana*), low juneberries (*Amelanchier humilis*), gray-bark dogwoods (*Cornus foemina*), wolfberries (*Symphoricarpos occidentalis*), and on lighter soils, prairie willows (*Salix humilis*), New Jersey tea (*Ceanothus americanus*), and American hazelnuts (*Corylus americana*). Leadplant (*Amorpha canescens*) was always present. The herbaceous vegetation was dominated by species typical of Mesic Prairie, but herbs typical of Oak Woodland and Oak Forest were probably present as well, especially beneath tree or shrub canopies.

Mesic Oak Savanna occurred on dry-mesic to mesic, gently undulating to moderately sloping sites. These sites were on glacial till or outwash, with soil texture ranging from clay loam to sandy loam. Mesic Oak Savanna generally occurred on sites where fire was frequent enough to prevent trees and shrubs from forming closed canopies, thereby permitting heliophilous prairie herbs to dominate the groundlayer. However, fire frequencies were lower than in prairies on similar topography and soils. Native grazing and browsing animals may also have helped maintain the open character of Mesic Oak Savanna. Out in the prairie zone, Mesic Oak Savanna occurred where either topographic features or wetlands, lakes, or streams created local fire "shadows" (areas of reduced fire frequency). Occurrences here were usually small. Closer to the deciduous forest-woodland zone and within it, where landscape character reduced fire frequency on a larger scale, Mesic Oak Savanna often covered larger areas. With settlement and the suppression of prairie fires, savannas in the deciduous forest-woodland zone that escaped clearing and cultivation quickly succeeded to woodland unless heavily and continuously grazed. No good quality examples are known.

Four geographic sections of Mesic Oak Savanna can be delineated, corresponding to the geographic sections delineated for Mesic Prairie (Fig. 13). Presettlement savannas on level outwash sands flanking the Mississippi River north of the Twin Cities and on mesic sites in the Anoka Sand Plain may have constituted a Sand Subtype, corresponding to the hypothetical Sand Subtype of Mesic Prairie.

Dry Oak Savanna

This dry to dry-mesic community is most common in the deciduous forest-woodland zone, but also occurs sporadically throughout the prairie zone (Fig. 1). The principal trees are bur oaks and northern pin oaks, but black oaks are also common in the southeast. Northwards,

quaking aspens become more frequent in the community. The stature and spacing of trees is somewhat variable, reflecting differences in soils, topography, and climate, factors that strongly affect local droughtiness and fire frequency. Small, gnarly, open-grown trees are most common, although in moister spots, or in heavier soils, larger trees are sometimes more common. Tree spacing ranges from sparsely and evenly distributed to strongly clumped in moderately dense patches. Shrub cover is variable as well. The species composition of the shrub layer depends somewhat upon soil characteristics. Oak grubs and chokecherries are common on all soil types. On sandier soils, prairie willows (*Salix humilis*), New Jersey tea (*Ceanothus americanus*), American hazelnuts (*Corylus americana*), sand cherries (*Prunus pumila*), and juneberries (*Amelanchier* spp.) are usually present. Wolfberries (*Symphoricarpos occidentalis*) are commoner on heavier soils.

Dry Oak Savanna occurs on the same kinds of landforms as Dry Prairie, except for bedrock bluffs. Correspondingly, substrates range from excessively-drained to well-drained, sand to loam soils. The presence of savanna rather than prairie indicates a lower fire frequency or intensity (or both) than in prairie. Dry Oak Savanna requires less frequent fire than Mesic Savanna for maintenance. However, in the complete absence of fire woodland will eventually replace Dry Oak Savanna. Grazing and browsing animals may also have had a role in the maintenance of Dry Oak Savanna. Because Dry Oak Savanna occurs on sites that are not as suitable for cultivation as Mesic Savanna sites, and because succession in the absence of fire is not as rapid, more examples remain of Dry Oak Savanna than of Mesic Oak Savanna.

There are four geographic sections of Dry Oak Savanna (Southwest, Southeast, Central, and Northwest (Fig. 13)), and threes subtypes (Barrens, Sand-Gravel, and Hill). The subtypes are closely associated with the equivalent Dry Prairie subtypes. Not all subtypes occur in every section. Additional details of the subtypes follow.

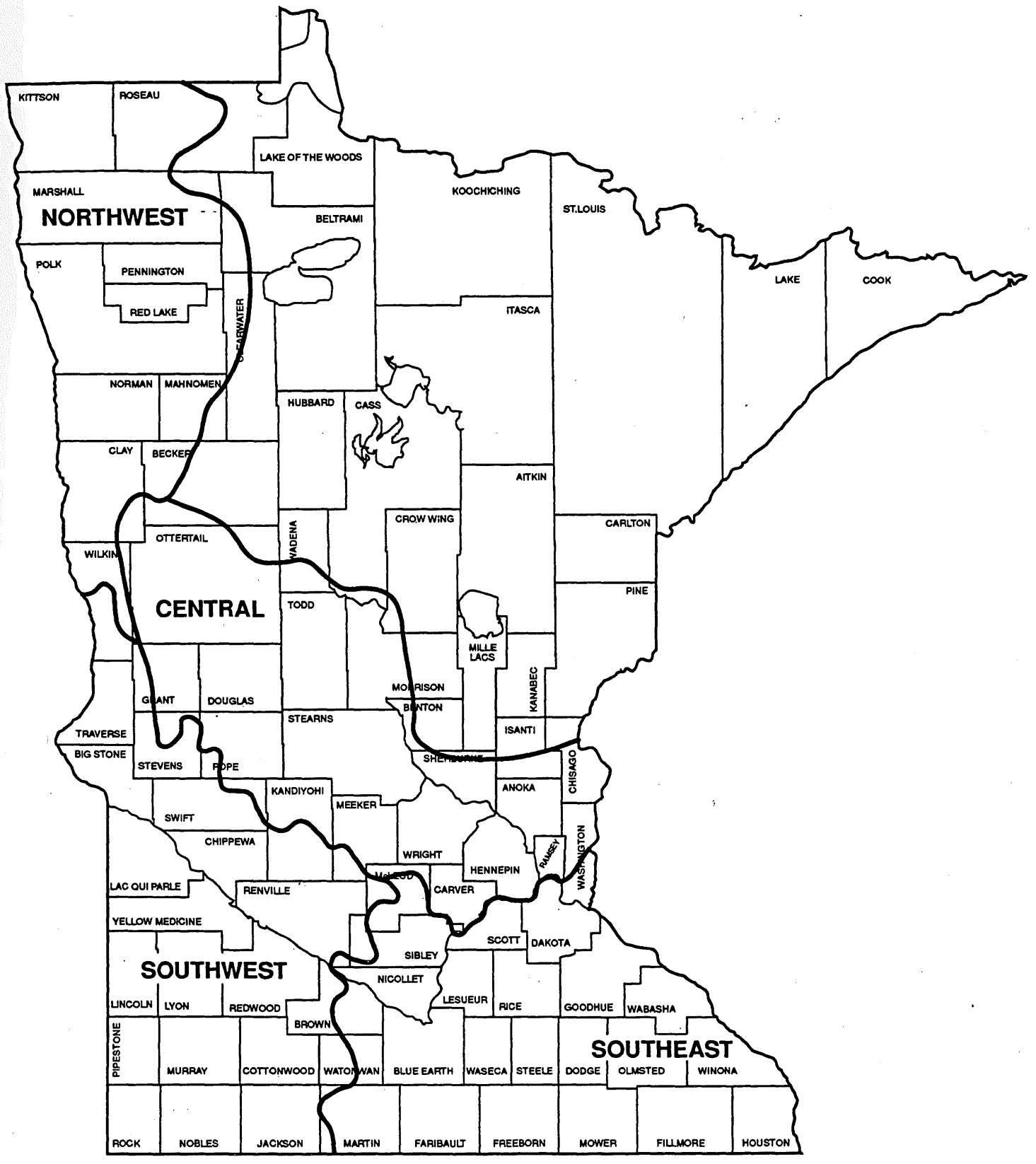
c. substrate sand (gravel fraction $< 10\%$) with little soil formation; present on dunes or on steep, erodible alluvial sand deposits such as some alluvial fans or stream cuts; herbaceous vegetation in open areas similar to that of Dry Prairie Barrens Subtype ..... *Barrens Subtype*

c. substrate with various textures or, if sandy, gravel fraction $> 10\%$; usually some soil formation ..... **d.**

d. savanna on alluvium, mostly of glacial origin (glacial lake beachlines, kames, eskers, collapsed outwash, abandoned river terraces, etc.); soils coarse textured, gravel fraction $> 10\%$; present on gentle to steep slopes; herbaceous vegetation in open areas similar to Dry Prairie Sand-Gravel Subtype ..... *Sand-Gravel Subtype*

d. savanna on glacial till, on depositional or erosional slopes; soils fine- to medium-textured loams, gravel fraction various; slopes $> 10\%$; herbaceous vegetation in open areas similar to that of Dry Prairie Hill Subtype ..... *Hill Subtype*

Figure 13. The Southeast, Southwest, Central, and Northwest Sections of Mesic Oak Savanna and Dry Oak Savanna.



Barrens Subtype

This subtype occurs on the same kinds of sand deposits as the Barrens Subtype of Dry Prairie. On dune blankets it tends to be favored over prairie in areas of sharper relief. Bur oaks are generally the prevalent trees; northern pin oaks are also common in the Central Section, and black oaks are common in the Southeast Section. In the Northwest and Central Sections quaking aspens are common in moister spots (this may represent post-settlement invasion). Trees range in spacing from sparse and evenly spaced to strongly clumped. The shrub layer is usually sparse; the most common species are oaks (in the form of grubs), chokecherry, American hazel, smooth sumac, and prairie willow. Creeping juniper (*Juniperus horizontalis*) is common in the northwest, and bush juniper (*Juniperus communis*) and New Jersey tea (*Ceanothus americanus*) are usually present in the Central and Southeast Sections. The herbaceous vegetation present in open areas is similar to that of the Barrens Subtype of Dry Prairie.

This subtype grades into the Sand-Gravel Subtype of Dry Oak Savanna. The Barrens Subtype occurs in the Southeast, Central, and Northwest Sections of the community.

Sand-Gravel Subtype

This subtype of Dry Oak Savanna occurs on the same kinds of sites as the Sand-Gravel Subtype of Dry Prairie. Such sites are more likely to be savanna than prairie in the far northwest and within the deciduous forest-woodland zone. Occurrences tend to be small. The oak species composition has the same geographic pattern as in the Barrens Subtype of Dry Oak Savanna, and again quaking aspen becomes important northwards. The shrub species are essentially the same as in the Barrens Subtype, but the shrub layer is generally denser. American hazels, chokecherries, and juneberriws (*Amelanchier* spp.) predominate. Wolfberries are frequent. The herbaceous vegetation is similar to that of the Sand-Gravel Subtype of Dry Prairie. The Sand-Gravel Subtype of Dry Oak Savanna succeeds to woodland more rapidly than the Barrens Subtype.

As noted above, examples of this subtype on outwash material may be difficult to distinguish floristically from the Barrens Subtype. The Sand-Gravel Subtype occurs in the Southeast, Central, and Northwest Sections of Dry Oak Savanna.

Hill Subtype

This subtype occurs on the same kinds of sites as the Hill Subtype of Dry Prairie. Occurrences are concentrated along the ecotone between the prairie and deciduous forest-woodland zones (Fig. 1), and tend to be small. Bur oak and northern pin oak are the major oak species; aspen becomes important northwards. The most common shrubs are chokecherries,

wolfberries, and smooth sumacs. Leadplant is always present. The density of the shrub layer is highly variable. The herbaceous vegetation of open areas between trees is essentially the same as that of the Hill Subtype of Dry Prairie. This subtype succeeds to woodland almost as rapidly as Mesic Oak Savanna except on the steepest, droughtiest slopes. Therefore, few examples remain. Most surviving examples have a history of fairly heavy grazing.

The Hill Subtype occurs in the Southwest, Southeast, and Central Sections of Dry Oak Savanna.

Aspen Openings

Aspen Openings are fine-grained mosaics of aspen groves and prairie or brush-prairie. They occur in the northern part of the deciduous forest-woodland zone (Fig. 1). The dominant trees are quaking aspens, which frequently are mixed with balsam poplars; bur oaks are sometimes present on drier sites. The aspen and balsam poplar groves consist predominantly of young trees that originated from scattered mature trees by root suckering following fire. The bur oaks are usually small, spindly, and overtopped by the aspens and poplars, but larger well-formed trees are not uncommon.

Aspen openings exist on sites ranging from wet to mesic. The understory composition in the tree groves and prairie openings varies with this range in moisture. Understory vegetation within the tree groves is often similar to that of Aspen Woodland. However, in young occurrences that have recently invaded prairie, prairie herbs and shrubs dominate the understory vegetation.

Aspen Openings develop on nearly level to gently undulating topography. On low sites, aspen groves occur in the better-drained areas and wet prairie occurs in the open areas between groves. On more mesic sites, especially southward, aspen groves often have developed in wet-mesic to wet depressions, with mesic prairie present in better-drained areas between the groves. Historically, Aspen Openings existed where fire was frequent or intense enough to prevent complete succession to woodland. In the prolonged absence of fire, Aspen Openings succeed to Aspen Woodland, with only the wettest areas (i.e., Wet Meadow and Marsh areas) remaining open. Drought stress is also important in maintaining Aspen Openings, and often interacts with fire. Most modern examples of Aspen Openings probably represent succession from Brush Prairie (where quaking aspen and balsam poplar were present but rarely reached tree size) following fire suppression, or from the invasion of other prairie types by aspen following fire suppression. It is not known whether Aspen Openings can be maintained as a stable type or whether occurrences are always transitory.

There is one recognized subtype of Aspen Openings, the Sand-Gravel Subtype. The Sand-Gravel Subtype is a dry-mesic to mesic savanna present in areas of undulating outwash with coarse-textured gravelly soils (gravel fraction $>10\%$). The herbaceous vegetation in openings between aspen groves is similar to that of the Sand-Gravel Subtype of Upland Prairie.

Aspen Openings is a scale-dependent community, as it is a composite of prairie communities and Aspen Woodland. Because of this, the placement of boundaries between Aspen Openings and Aspen Woodland or between Aspen Openings and Brush-Prairie communities is usually subjective.

CONIFEROUS WOODLAND

Coniferous Woodlands occur in the conifer-hardwood forest and deciduous forest-woodland zones (Fig. 1). They have interrupted tree canopies dominated by jack pines (or occasionally by black spruces and red pines), and have relatively continuous subcanopies of stunted oaks, young aspens, hazelnuts, cherries, or dogwoods. Areas under small openings in the tree canopy have either low-growing ericaceous shrubs, mosses, lichens, forest graminoids, and species characteristic of primary communities or dry prairie species.

Coniferous Woodlands are early successional communities but tend to persist for long periods, either because they occur on sites with soils poorly suited for tree growth, or because they occur on sites prone to repeated fire. For example, Coniferous Woodlands often originate following the burning of Coniferous Forests on sites with nutrient-poor droughty soils; although these woodlands then succeed toward coniferous forest, tree growth and canopy development are so slow that a distinct woodland persists on the site for long periods. Early land surveyors described stands of pine-dominated woodland on relatively rich prairie soils on outwash plains in the deciduous forest-woodland zone. These woodlands existed in areas (along rivers, old village sites) that appear to have been burned frequently by Native Americans, which promoted the regeneration of jack pine. Most of these areas are now cultivated and the remaining pine woodlots are succeeding to Mixed Oak Forest in the absence of fire. Modern communities that fit the general description of Coniferous Woodland include small relics of pine woodlands, overgrown coniferous savanna, and areas degraded by post-logging slash fires and erosion.

There are two Coniferous Woodland community types. Both types--Jack Pine Woodland and Northern Conifer Woodland--are floristically similar to their savanna counterparts, as they usually contain some of the species characteristic of savanna openings. In general, Northern Conifer Woodland originates following the burning of Coniferous Forests on sites with very poor soils, while Jack Pine Woodland originates on sites with fertile soils and frequent fires.

a. trees mostly jack pine; habitat typically dry sandy prairie soils; openings brushy and with both shade-tolerant forest and prairie forbs and graminoids ..... ***Jack Pine Woodland***

a. trees mostly jack pine, black spruce, or both; habitat dry, mostly shallow soils over bedrock; openings brushy and with groundlayer of species associated with forests and Primary Communities ..... ***Northern Conifer Woodland***

Jack Pine Woodland

Jack Pine Woodland occurs on outwash plains along the border between the conifer-hardwood forest and deciduous forest-woodland zones (Fig. 1). The canopy is dominated by jack pines (the open-cone ecotype), with large red pines occasionally forming a sparse supercanopy above the jack pine canopy. Pin oak and bur oak grubs and juvenile aspens occur

in the understory. The shrub layer is tall, dense, and continuous, with American hazel, downy arrowwood, juneberry, and prairie willow as dominant species. The groundlayer usually is sparse and is composed of dry woodland species and prairie species capable of persisting beneath the densely growing shrubs.

Jack Pine Woodland is best known from historical descriptions of pine woodlands that were present near prairie inclusions in forested regions. The prairie areas were gathering sites for Native Americans, and it is believed that the woodlands were largely maintained by fires set in the adjacent prairie openings. All of these pine woodlands occurred on prairie soils, which attests to their recent origin (within the past 600 years), when jack pines invaded areas of Brush-Prairie. Because the prairie soils are good agricultural soils, most Jack Pine Woodlands have been cleared for cropland and very few remain. Most of the remnants occur as scattered woodlots within agricultural areas and are succeeding to Mixed Oak Forest in the absence of fire.

There are no subtypes or sections of Jack Pine Woodland.

Northern Conifer Woodland

Northern Conifer Woodland occurs in the conifer-hardwood forest zone (Fig. 1), primarily on the thin rocky soils of the Canadian shield (Fig. 7) and less often on poor sandy soils in outwash areas. The canopy is sparse to patchy, with 10 to 70% cover, and is dominated by jack pines, sometimes mixed with upland black spruces or red pines. Northern red oaks, pin oaks, and, occasionally, bur oaks are present in the subcanopy.

The shrub layer is comparatively short (less than 1.5m tall) and ranges in cover from patchy to continuous. Prairie willows, Bebb's willows, juneberries, beaked hazels, bush honeysuckles, and blueberries are the common shrubs. Beneath the tree canopy the groundlayer is composed of species characteristic of xeric forests, while in rocky or sandy openings the predominant groundlayer species are species characteristic of Primary Communities, especially Rock Outcrop communities.

Northern Conifer Woodland is an early successional community maintained by fire. The community is physiognomically and floristically intermediate between Northern Conifer Scrubland and Coniferous Forest communities, particularly Jack Pine Forest. Some modern stands that are classified as Northern Conifer Woodland are actually Coniferous Forest or Mixed Coniferous-Hardwood Forest community types that have been degraded by intensive logging.

There are no recognized subtypes or sections of Northern Conifer Woodland. An analysis of land survey records and evaluation of the effects of logging on some forest types may result in the recognition of subtypes or sections.

CONIFEROUS SAVANNA

Coniferous Savannas occur mostly within the conifer-hardwood forest zone (Fig. 1) although they are not widespread and probably were not common even before extensive settlement in Minnesota. The tree canopy of Coniferous Savannas is patchy or discontinuous and is dominated by either jack pines or black spruces. Stunted oaks and young aspens usually occur in the understory. Openings in the tree canopy are dominated either by low-growing ericaceous shrubs, mosses, lichens, and forest graminoids, or by dry prairie species.

There are two Coniferous Savanna community types, which were identified by examining public land survey records and by examining some of the few remaining stands.

a. trees predominantly jack pine; habitat typically dry sandy soils; openings have groundlayer composed of species characteristic of prairies ..... ***Jack Pine Barrens***

a. trees predominantly stunted jack pine, balsam fir, and white spruce, occasionally black spruce; habitat typically dry shallow soils over bedrock; openings have groundlayer composed of ericaceous shrubs and species characteristic of rock outcrop communities ....***Northern Conifer Scrubland***

Jack Pine Barrens

Jack Pine Barrens occur on extremely droughty, nutrient-poor dune fields along the border between the conifer-hardwood and deciduous forest-woodland zones (Fig. 1) in central Minnesota. The tree canopy is patchy and most often is composed purely of jack pines, although occasionally scattered red pines may be present. The deciduous tree species that occur in the community--primarily pin oak and bur oak--are usually present as fire-stunted subcanopy grubs and only rarely grow into the canopy. Jack Pine Barrens have a sparse tall-shrub layer, composed mostly of American hazelnuts, juneberries, and downy arrowwoods. The groundlayer is sparse, mainly because of the droughty, infertile soils on which the community occurs, and consists of a mixture of sand prairie species and common herbs of dry woodlands.

Jack Pine Barrens is a fire-maintained community. An analysis of fire scars on jack pines in a stand near Brainerd suggests that fires historically occurred in the community every ten years or less. Many of these jack pines have multiple fire scars on their trunks, indicating that most fires are low-intensity ground fires. This type of fire regime is very likely the result of the sparsely vegetated groundlayer in the community, which rarely contains enough biomass to fuel hot crown fires. Thus, it appears that Jack Pine Barrens are maintained by frequent, low-intensity ground fires. Occasionally, however, fires may kill some of the trees in the community, contributing to the formation of the patchy canopy characteristic of savannas. The fires also repeatedly burn back the oak shoots, maintaining the oaks in the community as grubs. The ground fires also may contribute to the open nature of the understory, by preventing the

development of a dense shrub layer. At the same time, the droughty, infertile sites on which the community occurs probably slow or prevent the development of a dense shrub layer even in the absense of fire. In the past, grazing by native herbivores may also have been important in maintaining the open structure of the community.

Structurally, Jack Pine Barrens are somewhat similar to Jack Pine Woodland. However, Jack Pine Woodland occurs on comparatively rich prairie soils on outwash, lacks a sand prairie understory, and has a dense shrub understory. There are no recognized subtypes or sections of Jack Pine Barrens.

Northern Conifer Scrubland

Northern Conifer Scrubland occurs on bald rock ridges on the Canadian Shield (Fig. 7) in the conifer-hardwood forest zone. The canopy is usually dominated by closed-cone jack pines, however white spruces and balsam firs sometimes dominate the community along the north shore of Lake Superior. Black spruces are present in occurrences of the community in Lake and Cook counties.

The conifer trees in the canopy grow scattered among shorter northern red oaks and clumps of Bebb's willow. Areas without trees contain either a drought resistant, low-shrub layer of bush honeysuckles, juneberries, beaked hazels, and blueberries, or primary rock outcrop communities composed of mosses, lichens, and vascular species such as wintergreen (*Gaultheria procumbens*), pale corydalis (*Corydalis sempervirens*), bristly sarsaparilla (*Aralia hispida*), and three-toothed cinquefoil (*Potentilla tridentata*).

Northern Conifer Scrubland is an early successional community that originates following severe fires in coniferous forests on rocky sites. These fires remove all the duff and moss or lichen cover from the ground surface, exposing bare rock and patches of bare soil (where soil has accumulated in depressions and crevices in the rock). The bare soil patches are recolonized by conifer species (particularly the fire-adapted jack pine), setting the pattern for the patchy tree canopy characteristic of the community.

There are no recognized subtypes or sections of Northern Conifer Scrubland. Northern Conifer Scrubland grades into the Jack Pine-Oak Subtype of Jack Pine Forest. Similar communities (called lichen woodlands) with scattered spruces and jack pines have been described at the northern edge of the Boreal Forest in Canada.

UPLAND BRUSH-PRAIRIE

Upland Brush-Prairies are open communities composed of various amounts of low brush in a herbaceous matrix of prairie species (Appendix 3). The distributions of prairie grass and forb species in Upland Brush-Prairies correlate with changes in soil moisture along a gradient from wet-mesic to dry-mesic that parallels the moisture gradient-species distribution pattern present in mesic Upland Prairies. Upland Brush-Prairies differ from mesic Upland Prairies mainly by having many shrub species that do not occur in mesic Upland Prairies. Additionally, Upland Brush-Prairies frequently have significant numbers of small aspens, often with balsam poplars and, on drier sites, bur oak grubs and stunted trees.

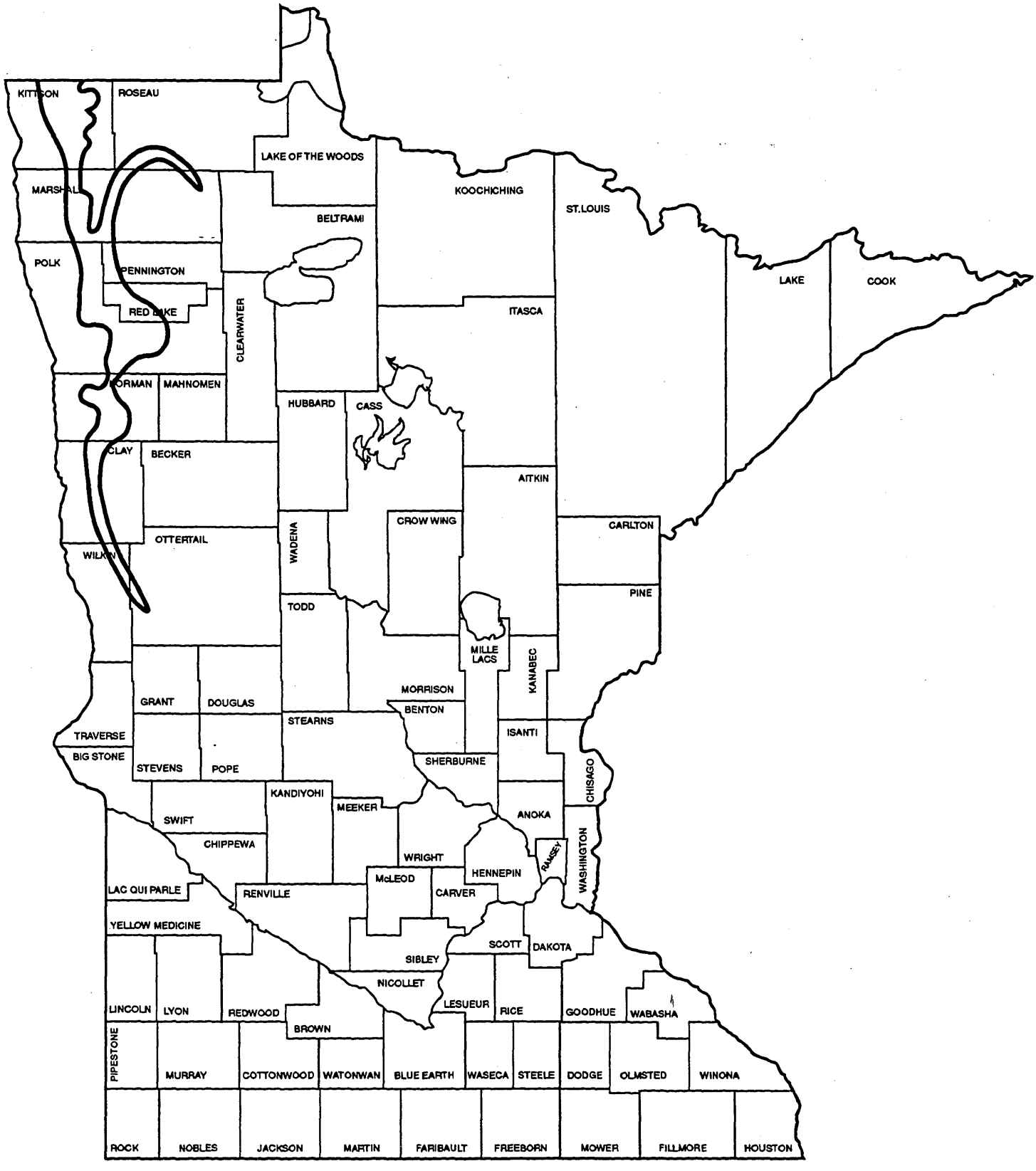
Frequent fire is important in maintaining Upland Brush-Prairies, although there appears to be a threshold of fire frequency and intensity (see below), beyond which Upland Brush-Prairies are replaced on the landscape by brush-free prairie types. In the past, bison and elk activity may also have helped to maintain Brush-Prairie communities. Where they have not been otherwise tilled for cropland, most small remnants of Upland Brush-Prairie have succeeded to woodland because of suppression of wild fires.

Although brushy areas are a common feature of prairie throughout the deciduous forest-woodland zone, these areas usually are localized patches or thickets in depressions or in association with topographic and aquatic features that provide protection from fire. However, in the far northwestern part of the deciduous forest-woodland zone, brush is more uniformly distributed in the prairie (and species are present that are rarely or never present southward) and true Upland Brush-Prairie occurs.

On the pre-settlement landscape in northwestern Minnesota, Upland Brush-Prairie and the closely associated Wet Brush-Prairie were the predominant prairie types on the Glacial Lake Agassiz Interbeach Area (Fig. 14), while just to the west on the Lake Agassiz Plain the prairies were mostly brush free. Southward within the Interbeach Area, brush prairies also gave way to standard prairie types, although Wet Brush-Prairie persisted farther southward than Upland Brush-Prairie. This suggests that a climatic gradient may have been important in causing the replacement of brush prairie, to the west and south, by brush-free prairie. That is, the cooler climate in the northwest reduced the frequency and severity of moisture stress and the intensity of fire so that, in general, brush would have a greater tendency to persist in prairie areas in the northwest. Superimposed on this climatic gradient, the Interbeach Area may have had a slight reduction in fire frequency, relative to the glacial lake plain to the west, because of its subtly greater relief and its edaphic heterogeneity. These differences may have been enough to tip the balance and prevent elimination of woody species from the prairies in the northern part of the Interbeach Area.

There is only one recognized Upland Brush-Prairie community type. However, additional data from other regions of the state may lead to the inclusion of other Upland Brush Prairie types or to reducing the existing type to a sectional variant of a more broadly defined community type.

Figure 14. The Glacial Lake Agassiz Interbeach Area of Northwestern Minnesota.



a. represented by a single type; vegetation dominated by a mixture of prairie grasses (Appendix 3) and brush composed of young aspen, scrub oak, and hazelnut ..... ***Mesic Brush-Prairie***

Mesic Brush-Prairie

(See Upland Brush-Prairie class description above for general description.) The major grasses of Mesic Brush-Prairie are big bluestem (*Andropogon gerardii*), and prairie dropseed (*Sporobolus heterolepis*) on all sites, little bluestem (*Schizachyrium scoparium*), junegrass (*Koeleria macrantha*), and porcupine grass (*Stipa spartea*) on drier sites, and bog reed-grass (*Calamagrostis inexpansa*), prairie cordgrass (*Spartina pectinata*), and mat muhly (*Muhlenbergia richardsonis*) on moister sites. Wheatgrass (*Agropyron trachycaulum*) is also generally common in the community; Indiangrass (*Sorghastrum nutans*) is present only occasionally. Mesic Brush-Prairie contains the usual forbs of Mesic Prairie and a few species more typical of woodland, including black snakeroot (*Sanicula marilandica*), carrion-flower (*Smilax lasioneura*), spreading dogbane (*Apocynum androsaemifolium*), and the sedge *Carex pensylvanica*.

The brush layer within the community is generally less than 1.5 meters tall, with total cover ranging from 30 to 50 percent. The major shrub species present are slender willow, pussy willow, bog birch, and shrubby cinquefoil on wet-mesic sites; Bebb's willow on mesic to wet-mesic sites; hazel, saskatoon, and chokecherry on dry-mesic and mesic sites; and prairie willow and leadplant on better-drained sandy sites. Sand cherry is present on most sites, but is generally not abundant or important except on sandy sites. Quaking aspen suckers or small saplings often form dense thickets in the community; grubs and stunted trees of bur oak are common on dry sites. Scattered groves of larger aspen are also common, while larger oaks are present only occasionally.

Mesic Brush-Prairie generally occurs on somewhat poorly drained to well-drained, sandy clay loam to loamy fine sand soils. These soils form in lake-washed glacial till or in sandy lacustrine deposits (of variable thickness) over till. Mollisols predominate, but entisols are also common; most soils are strongly calcareous.

On the landscape, Mesic Brush-Prairie occurs on nearly level terrain, often in a mosaic with Wet Brush-Prairie and brushy Wet Meadow. Distinguishing between Mesic Brush-Prairie and Wet Brush-Prairie may be difficult in these cases, as the two communities share many species. In some sandy areas, Mesic Brush-Prairie grades into typical Mesic Prairie. Brush and trees may actually be common in the Mesic Prairies in these areas but are more localized (in clumps and thickets) than in Mesic Brush-Prairie. On beach ridges and other dry, gravelly sites Mesic Brush-Prairie grades into an oak scrub or savanna community. Where aspen cover increases, Mesic Brush-Prairie grades into Aspen Openings.

Mesic Brush-Prairie is a fire-dependent community. In the absence of fire, trees become more abundant in the community and it eventually succeeds to woodland. Examination of public land survey records from the late 1800s in fact indicates that tree cover is now greater in most

Mesic Brush-Prairies in Minnesota than it was in the past. If fires occur in the community only occasionally, they may actually advance succession to woodland by stimulating aspen root suckering and the production of more aspen shoots.

Mesic Brush-Prairie has a very restricted distribution; there are no geographic sections of the community. There is one recognized subtype, a Sand-Gravel Subtype, which occurs locally on coarse-textured outwash deposits. Occurrences of the Sand-Gravel subtype are dry-mesic to mesic prairies in which porcupine grass (*Stipa spartea*) is the major grass species. Leadplant and (especially) prairie willlow are important shrubs.

UPLAND PRAIRIE

Upland Prairies occur primarily in the prairie zone, with scattered occurrences in the deciduous forest-woodland zone (Fig. 1). They are dominated by grasses. The tall grasses, big bluestem (*Andropogon gerardii*) and Indiangrass (*Sorghastrum nutans*), are the major dominants on moist sites, while midheight grasses, such as little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), porcupine grass (*Stipa spartea*), and june grass (*Koeleria macrantha*), are important to dominant on drier sites. Prairie dropseed (*Sporobolus heterolepis*) is common on both dry and moist sites. Short grass species, including blue grama (*Bouteloua gracilis*) and needle grass (*Stipa comata*), are common on the most xeric sites. Forbs typically are abundant (but subdominant to the grasses) and may have high local diversity. Forb species composition varies with site moisture, although some forb species occur on almost all sites, moist or dry. Several low shrub or sub-shrub species are common on Upland Prairie; the most characteristic is leadplant (*Amorpha canescens*). Taller brush and trees are absent or scattered, however brush or woodland areas may be interspersed with prairie, usually in association with topographic and aquatic features that provide protection from fire.

The most important cause of variation in species composition in prairie communities is variation in soil moisture. The local soil moisture regime is determined by slope, aspect, proximity to the water table, and soil texture. On a regional scale, variation in species composition is primarily caused by climatic variation (i.e., the westward decline in precipitation and northward decline in temperature in Minnesota).

Upland Prairies occur on a range of landforms in the prairie zone, from nearly flat glacial lakeplains to steep morainic slopes. In the deciduous forest-woodland zone, prairies occur on droughty, level outwash areas and steep south- and west-facing slopes. The pre-European settlement distribution of prairie was related to the interaction of local fire frequency with growth rates of woody species: where conditions were favorable for rapid growth, more frequent fires were necessary to maintain prairie over savanna, woodland, or forest. Fragmentation of Upland Prairie since European settlement has reduced fire frequency throughout the prairie and deciduous forest-woodland zones, and most prairie remnants have more brush and trees than were present in the past.

There are two recognized Upland Prairie community types; each type has several subtypes. Quantitative analyses of plot data may eventually result in elevation of some of the subtypes to types.

a. level to rolling topography, slopes generally $<10\%$; habitat mesic; soils with mollic epipedon, clay-loam to loamy fine-sand texture, somewhat poorly to somewhat excessively drained ..... ***Mesic Prairie***

a. undulating to rough topography, slopes of various degrees; habitat dry to dry-mesic; soils with or without mollic epipedon; soil texture loamy sand to sand on gentle slopes or any texture on steep slopes; well drained to excessively drained ..... ***Dry Prairie***

Mesic Prairie

Mesic Prairie is a dry-mesic to wet-mesic grassland that occurs mainly in the prairie zone in southern and western Minnesota and sporadically in the deciduous forest-woodland zone (Fig. 1). Mesic Prairie is dominated by grasses. Big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and prairie dropseed (*Sporobolus heterolepis*) are the major native species on most sites, with little bluestem (*Schizachyrium scoparium*) and porcupine grass (*Stipa spartea*) important on drier sites, and switchgrass (*Panicum virgatum*) and prairie cordgrass (*Spartina pectinata*) common on wetter sites. The introduced grass Kentucky bluegrass (*Poa pratensis*) is present at most sites; its is a function of the site's disturbance history.

Forbs are abundant (but usually subdominant to grasses) and have high local diversity. Forb species-composition also varies locally with soil moisture. There is greater regional variation among forbs than among grasses. Common forb species include purple prairie-clover (*Petalostemon purpureum*), white prairie-clover (*P. candidum*), ground-plum (*Astragalus crassicarpus*), prairie-turnip (*Psoralea esculenta*), rough blazing-star (*Liatris aspera*), Canada goldenrod (*Solidago canadensis*), stiff goldenrod (*S. rigida*), Missouri goldenrod (*S. missouriensis*), prairie thistle (*Cirsium flodmani*), smooth aster (*Aster laevis*), stiff sunflower (*Helianthus rigidus*), Maximilian sunflower (*H. maximiliani*), smooth rattlesnake-root (*Prenanthes racemosa*), white sage (*Artemisia ludoviciana*), wood lily (*Lilium philadelphicum*), white camas (*Zigadenus elegans*), heart-leaved alexanders (*Zizia aptera*), prairie larkspur (*Delphinium virescens*), downy phlox (*Phlox pilosa*), hoary puccoon (*Lithospermum canescens*), tall cinquefoil (*Potentilla arguta*), alum-root (*Heuchera richardsonii*), wood-betony (*Pedicularis canadensis*), northern bedstraw (*Galium boreale*), prairie bird-foot violet (*Viola pedatifida*), oval-leaved milkweed (*Asclepias ovalifolia*), and showy milkweed (*A. speciosa*). Purple coneflower (*Echinacea angustifolia*) is common on drier sites in the western part of the community's range. Leadplant, prairie rose, sand cherry, wolfberry, and prairie willow are common low-shrub or sub-shrub species. Fragrant false indigo is common on moister sites. Trees and taller brush often occur along the margins of wetlands adjacent to Mesic Prairies.

Mesic Prairie is a fire-dependent community. In the absence of fire, occurrences of Mesic Prairie are invaded by brush and trees. In the prairie zone, Mesic Prairie occurs on nearly level glaciolacustrine and glaciofluvial deposits, and on flat or gently rolling morainic landforms. In southeastern and, to a lesser extent, southwestern Minnesota, the glacial deposits are overlain by loess. Bedrock subtypes of Mesic Prairie exist in a few areas where bedrock is within about one-and-one-quarter meters of the ground surface and there are numerous small patches of exposed rock. Within the deciduous forest-woodland zone, Mesic Prairie usually occurs on level outwash areas or on broad, sandy river terraces.

The soils in Mesic Prairie are predominantly mollisols with thick, dark mineral surface layers that have high base saturation and dominantly bivalent cations. They range in texture and drainage from silty and somewhat poorly drained to sandy and somewhat excessively drained, with moderately well-drained to well-drained, loamy soils being most common. Mesic Prairie grades into Wet Prairie on moister sites and into the Hill and Sand-Gravel subtypes of Dry Prairie on drier sites. Separation of Mesic Prairie from other prairie types is based primarily

on landform or substrate characteristics rather than on species composition, as floristic boundaries between Mesic Prairie and other prairie types are not well defined.

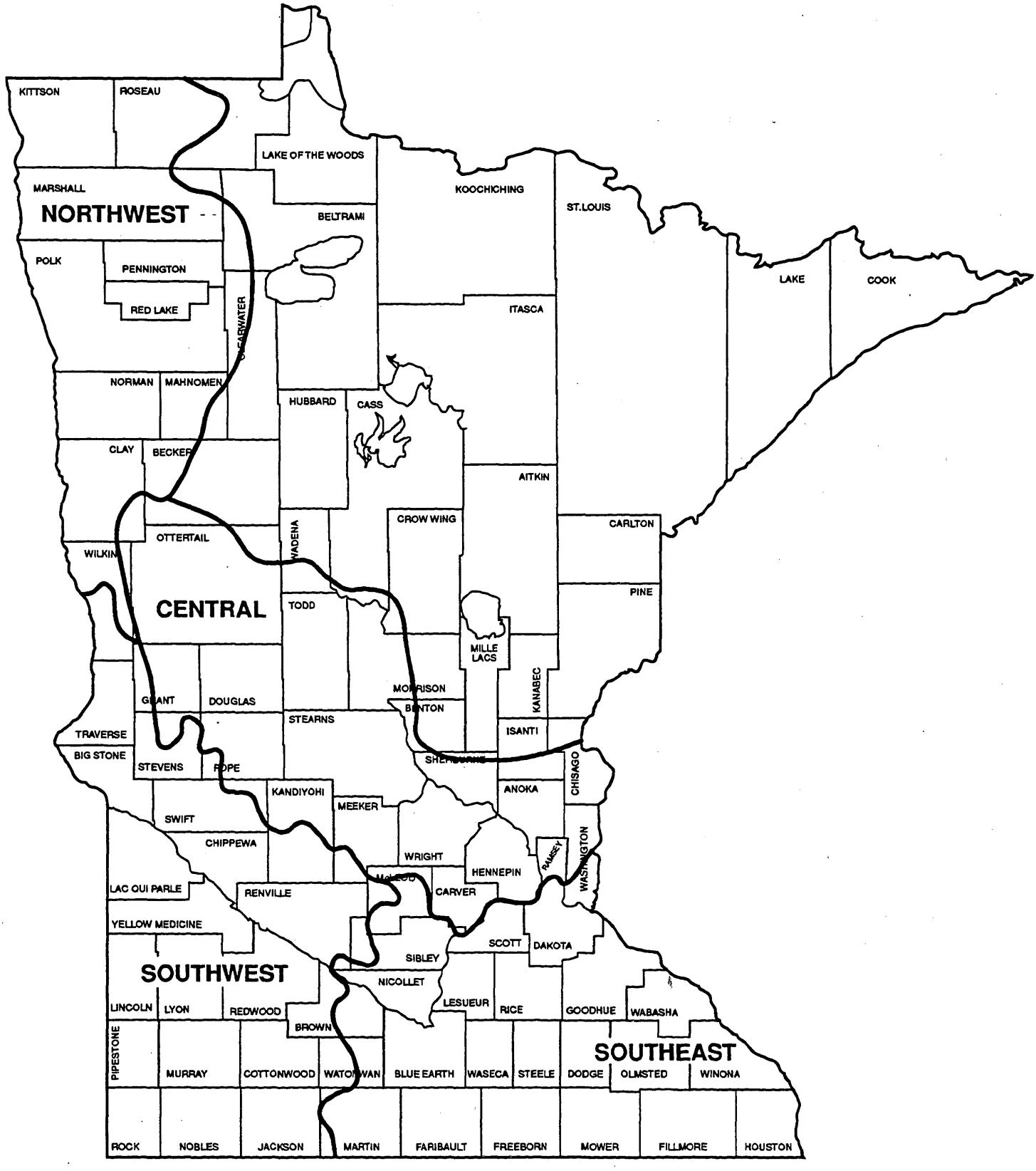
There are four geographic sections of Mesic Prairie (Southeast, Southwest, Central, and Northwest, Fig. 15) and two subtypes (Crystalline Bedrock and Carbonate Bedrock). The bedrock subtypes are rolling to level prairies on thin soils over bedrock. The Crystalline Subtype occurs on either quartzite or granite bedrock while the Carbonate Subtype occurs on dolomite or limestone bedrock. In both subtypes, the depth to bedrock is generally less than 1.25 meters, with bedrock often exposed at the ground surface. Revision of the geographic sections and additional subtyping according to soil properties is likely, following collection and analysis of additional plot data. Another distinctive subtype (a sand subtype) probably existed before European settlement on broad terraces along the Mississippi River from the Twin Cities to Brainerd. The soils of these terraces are mollisols (i.e., prairie soils), but are formed in deep outwash sands. No surviving examples of these prairies are known, although patches of prairie species growing in railroad-highway rights-of-way and other scattered spots give some indication of its former character.

Dry Prairie

Dry Prairie is a dry to dry-mesic herbaceous community dominated by grasses and sedges. It occurs throughout the prairie zone and sporadically in the deciduous forest-woodland zone (Fig. 1). Dry Prairie has considerable variation in species composition, reflecting interactions among geography (namely climate), soils, and topography. In general, Dry Prairies have a greater component of Great Plains species than Mesic Prairies, especially in prairies in the western part of Minnesota. Big bluestem (*Andropogon gerardii*) is always present in the community and usually important, but it does not achieve the dominance it typically has in Mesic Prairie. Indiangrass (*Sorghastrum nutans*) is more limited in occurrence, generally appearing only where conditions approach mesic. Mid-height and short grasses and sedges are usually dominant in Dry Prairie. Among the more common are porcupine grass (*Stipa spartea*), little bluestem (*Schizachyrium scoparium*), side-oats grama (*Bouteloua curtipendula*), prairie junegrass (*Koeleria macrantha*), and sun-loving sedge (*Carex heliophila*).

Forb variation within the community is more pronounced. Some widespread, characteristic species are dotted blazing star (*Liatris punctata*), pasque flower (*Pulsatilla nuttalliana*), prairie golden-aster (*Heterotheca villosa*), stiff sunflower (*Helianthus rigidus*), silky aster (*Aster sericeus*), green milkweed (*Asclepias viridiflora*), stiff goldenrod (*Solidago rigida*), gray goldenrod (*Solidago nemoralis*), Missouri goldenrod (*Solidago missouriensis*), and narrow-leaved puccoon (*Lithospermum incisum*). Dry Prairies share many forb species with Mesic Prairies, including rough blazing star (*Liatris aspera*), buffalo-bean (*Astragalus crassicarpus*), tooth-leaved evening primrose (*Calylophus serrulatus*), silverleaf scurfpea (*Psoralea argophylla*), thimbleweed (*Anemone cylindrica*), Louisiana sagewort (*Artemisia ludoviciana*), prairie larkspur (*Delphinium virescens*), heartleaved alexanders (*Zizia aptera*), purple prairie-clover (*Petalostemon purpureum*), hoary puccoon (*Lithospermum canescens*), prairie smoke (*Geum triflorum*), and wood lily (*Lilium philadelphicum*).

Figure 15. The Southeast, Southwest, Central, and Northwest Sections of Mesic Prairie and Dry Prairie.



Three sub-shrubs--leadplant (*Amorpha canescens*), prairie rose (*Rosa arkansana*), and wolfberry (*Symphoricarpos occidentalis*)--typical in Mesic Prairies are also generally present in Dry Prairie. Soil-encrusting lichens and the fern-ally rock-spikemoss (*Selaginella rupestris*) are often common in Dry Prairie. Brush, and sometimes trees, may be present in hollows and draws. Bur oak (*Quercus macrocarpa*), chokecherry (*Prunus virginiana*), wild plum (*Prunus americana*), and smooth sumac (*Rhus glabra*) are the most widespread woody species. Other woody species more limited in distribution in the community are northern pin oak (*Quercus ellipsoidalis*), black oak (*Quercus velutina*), and hazel (*Corylus americana*).

Dry Prairies are maintained by fire but require less frequent fires than mesic and wet prairies because the droughty conditions within Dry Prairies slow or prevent the growth of woody species. Dry Prairie occurs on a variety of landforms, including sand dune blankets of mid-Holocene origin, glacial lake beach ridges, outwash deposits, ice-contact features (kames, eskers), morainic hills, erosional slopes in glacial drift, and bedrock-cored bluffs. Soils range from nearly pure sand with little profile development, to mollisols, although the latter have a much thinner organic-rich surface horizon than the soils of Mesic Prairie. All overlie deep glacial drift except for those of the bedrock-cored bluffs, which are formed in a thin layer of loess or residuum. Soils are well drained to excessively drained. Depending upon the degree of slope, the slope aspect, and the soil composition, Dry Prairie intergrades with Mesic Prairie.

There are four Dry Prairie subtypes. The Barrens Subtype, which occurs primarily on old dune blankets, is perhaps most distinctive, and additional plot data may support recognizing it as a separate community type. The Bedrock Bluff Subtype may also deserve type status. There are four geographic sections of Dry Prairie (Southeast, Southwest, Central, and Northwest), each having the same boundaries as the equivalent sections of Mesic Prairie (Fig. 15). Not all subtypes occur in every geographic section. Additional details of the subtypes follow:

d. substrate sand (gravel fraction $< 10\%$) with little soil formation; present on dunes or on steep, erodible alluvial sand deposits such as some alluvial fans or stream cuts ....*Barrens Subtype*

d. substrate variable in texture or, if sandy, gravel fraction $> 10\%$; usually some soil formation ..... **e.**

e. site on alluvium, mostly of glacial origin (glacial lake beachlines, kames, eskers, collapsed outwash, abandoned river terraces, etc.); soils coarse textured, gravel fraction $> 10\%$; present on gentle to steep slopes ....*Sand-Gravel Subtype*

e. site not on alluvium, mostly on dissected till or bedrock; soils fine to medium textured, gravel fraction variable; slopes $> 10\%$ ..... **f.**

f. soils on unconsolidated drift; slopes moderate to steep ... *Hill Subtype*

f. thin soils over bedrock; typically on steep bluffs .....
..... *Bedrock Bluff Subtype*

Barrens Subtype

The Barrens Subtype occurs on dry to dry-mesic sands on outwash plains, old dune blankets, and alluvial deposits along rivers and streams. It is present in the northwest, central, and southeastern parts of the prairie zone, and also in the deciduous forest-woodland zone. The low nutrient levels, low levels of organic matter, and poor water-retaining capacity of the deep sands presumably are the major determinants of the species composition and structure of the subtype. The vegetation is generally sparser than in other Dry Prairie subtypes (often with less than 50% cover), but is fairly rich floristically. The major graminoid species in the subtype include all of the common graminoids listed above for Dry Prairies in general, exclcuding side-oats grama. Other graminoids characteristic of the Barrens Subtype are sand dropseed (*Sporobolus cryptandrus*), sand reedgrass (*Calamovilfa longifolia*), hairy grama (*Bouteloua hirsuta*), blue grama (*Bouteloua gracilis*), and several sedges, notably *Carex foenea* and *Cyperus schweinitzii*.

Among the more distinctive forbs that occur in this subtype are prairie sagewort (*Artemisia frigida*), plantain-leaved pussytoes (*Antennaria plantaginifolia*), large-flowered beard-tongue (*Penstemon grandiflorus*), hairy puccoon (*Lithospermum caroliniense*) (in the southeast and central parts of the state), and silky prairie-clover (*Petalostemum villosum*). Prairie willow (*Salix humilis*) is generally a common low shrub in this subtype. Several plant species characteristic of the Barrens Subtype (for example, false heather (*Hudsonia tomentosa*)) are restricted to local disturbances such as active blowouts or slipfaces.

The Barrens Subtype often occurs as inclusions in areas of Dry Oak Savanna or Oak Woodland. Whether to classify an area as Dry Prairie Barrens Subtype or as part of a savanna community depends upon the size of the prairie opening, or often upon the degree to which fragmentation has isolated small remnants. The Barrens Subtype grades into Mesic Prairie or even into Wet Prairie in low areas or where sand grades into richer soils.

The Barrens Subtype is present in the Northwest, the Central, and the Southeast Sections of Dry Prairie (Fig. 15). In the Northwest Section, the subtype occurs on dune blankets such as the Agassiz Dunes and Skull Lake Dunes. In the Central Section, occurrences are on outwash along the Mississippi River and on the Anoka Sand Plain. In the Southeast Section, the subtype is present on dunes on terraces along the Mississippi River (Weaver Dunes) and on sandy alluvial fans at Whitewater Wildlife Management Area and Rushford Sand Barrens SNA.

Sand-Gravel Subtype

The Sand-Gravel Subtype occurs on gently to steeply sloping sites throughout the prairie zone, with scattered occurrences in the deciduous forest-woodland zone (Fig. 1). In addition

to the widespread graminoids listed above in the general description of Dry Prairies, important species in the Sand-Gravel Subtype include needle grass (*Stipa comata*), plains muhly (*Muhlenbergia cuspidata*), prairie dropseed (*Sporobolus heterolepis*), Wilcox's panic grass (*Panicum wilcoxianum*), blue grama (*Bouteloua gracilis*), hairy grama (*Bouteloua hirsuta*), and sand reedgrass (*Calamovilfa longifolia*). Some distinctive forb species, in addition to those present in all Dry Prairie subtypes, are prairie sagewort (*Artemisia frigida*), plantain-leaved pussytoes (*Antennaria plantaginifolia*), purple coneflower (*Echinacea angustifolia*) (except in the southeast), skeleton-weed (*Lygodesmia juncea*), *small white beard-tongue* (*Penstemon albidus*), plains paintbrush (*Castilleja sessiliflora*), prairie cinquefoil (*Potentilla pensylvanica*), and the milk-vetch *Astragalus adsurgens*.

The Sand-Gravel Subtype of Dry Prairie occurs on the former shorelines of Glacial Lake Agassiz, on outwash deposits, and on ice-contact features such as kames and eskers. Occurrences are typically small, corresponding to the local extent of these landforms. Soils are mollisols ("prairie" soils), but the organic-rich surface horizon is thinner than in Mesic Prairie, and fine to coarse gravel constitutes a significant fraction of the solum. Soil texture is most commonly sandy-skeletal, often with abundant larger stones as well as gravel. These soils are excessively drained or somewhat excessively drained.

This subtype grades into the Barrens Subtype on outwash deposits, or even into the dry-mesic phase of Mesic Prairie. Distinguishing between the Sand-Gravel Subtype when it is present on steeply sloping collapsed outwash or ice-contact deposits and the Hill Subtype may be especially difficult. The Sand-Gravel Subtype occurs in the Southeast, Southwest, Central, and Northwest Sections of Dry Prairie (Fig. 15).

Hill Subtype

The Hill Subtype occurs on steep terrain throughout the prairie zone as far north as Polk County, and sporadically in the deciduous forest-woodland zone (Fig. 1). Depending upon slope position, angle, and aspect, as well as soil type, conditions vary from dry to mesic, although drier conditions predominate. Of the Dry Prairie Subtypes, the Hill Subtype has the greatest overlap in species composition with Mesic Prairie and is richest in species. The major graminoids include those listed above for all Dry Prairies, plus prairie dropseed (*Sporobolus heterolepis*); Indian grass (*Sorgastrum nutans*) and big bluestem (*Andropogon gerardii*) are more important in the Hill Subtype than in other Dry Prairie subtypes. Less abundant but characteristic graminoids include Wilcox's panic grass (*Panicum wilcoxianum*) and plains muhly (*Muhlenbergia cuspidata*). Typical forbs other than those common to all Dry Prairie subtypes include purple coneflower (*Echinacea angustifolia*), aromatic aster (*Aster oblongifolius*), plains paintbrush (*Castilleja sessiliflora*), small white beard-tongue (*Penstemon albidus*), locoweed (*Oxytropis lambertii*), and the milk-vetch *Astragalus adsurgens*).

The Hill Subtype occurs on erosional features in glacial till (e.g., valley side slopes), but also on steep slopes in disintegration moraine. Soils are mollisols but with shallower organic-rich surface horizons than in Mesic Prairie. Soil texture ranges from clay loam to sandy loam;

cobbles and boulders are often common and gravelly inclusions may also be present. Soils are excessively drained to well drained. Floristically, the boundary between the Hill Subtype of Dry Prairie and the dry-mesic phase of Mesic Prairie is particularly indistinct. They are best separated by topography. This subtype also grades into the hillier forms of the Sand-Gravel Subtype of Dry Prairie, as noted above. Heavily grazed occurrences of the Hill Subtype are often difficult to distinguish floristically from the Sand-Gravel Subtype. The Hill Subtype is present in the Southeast, Southwest, Central, and Northwest Sections of Dry Prairie (Fig. 15).

Bedrock Bluff Subtype

The Bedrock Bluff Subtype occurs on bluffs along the Mississippi River and many of its tributaries in southeastern Minnesota, and to a very limited extent along the St. Croix River. The community is best developed on very steep south- and west-facing slopes; goat prairie, the popular name of the community, indicates the steepness of these slopes. The major graminoid species in the Bedrock Bluff Subtype are those generally common graminoids to all dry prairies (see above). Other common graminoid species are prairie dropseed (*Sporobolus heterolepis*), plains muhly (*Muhlenbergia cuspidata*), hairy grama (*Bouteloua hirsuta*), Leiberg's panic grass (*Panicum leibergii*), and long-leaved panic grass (*Panicum perlongum*). Some of the more common distinctive forbs are plains paintbrush (*Castilleja sessiliflora*), aromatic aster (*Aster oblongifolius*), sky-blue aster (*Aster oolentangiensis*), cylindric blazing-star (*Liatris cylindracea*), false boneset (*Kuhnia eupatoroides*), birdfoot coreopsis (*Coreopsis palmata*), and flowering spurge (*Euphorbia corollata*).

Soils of the Bedrock-Bluff Subtype are thin and formed in loess or residuum on steep erosional bedrock slopes. The underlying bedrock is dolomite and sandstone. Cobble to boulder sized rock rubble is abundant, and bedrock outcrops are common. Soils are excessively drained to well drained. Occurrences of this community are usually small openings surrounded by woodland or forest, although there are some large bluffs that are completely covered by prairie.

The frequency and intensity of moisture stress on the steepest south- or west-facing slopes (summer soil temperatures often exceed 40 degrees C) greatly impede invasion of Bedrock Bluff Prairies by woody vegetation, but complete suppression of fire does result in eventual succession from prairie to savanna or dry woodland.

There are no geographic sections of Bedrock-Bluff Subtype.

BOG

Bogs occur primarily on the Agassiz, Aitkin and Upham glacial lake plains in the conifer-hardwood forest zone (Fig. 1). They also occur in scattered kettle-hole basins in the conifer-hardwood forest and deciduous forest-woodland zones. Bogs have a nearly continuous mat of moss dominated by *Sphagnum* species (especially *Sphagnum fuscum* and *Sphagnum angustifolium*), and an impoverished vascular flora. A forest canopy of black spruce may or may not be present. Tall shrubs are absent. The groundlayer is dominated by low ericaceous shrubs (Labrador tea, leatherleaf, swamp laurel, or bog-rosemary), sedges (*Carex* spp.), or cotton grasses (*Eriophorum* spp.). Although there are no indicator species of Bogs, Bogs can be identified by their paucity of minerotrophic species (they usually have at most 2 minerotrophic species present, with very low coverage). Appendix 6 lists plant species tolerant of bog (i.e, non-minerotrophic) environments.

Bogs are late-successional communities that develop in peatlands where the surface substrate has become isolated from groundwater flow because of peat accumulation. A minimum of one meter of peat, with a surface composed of poorly decomposed minerotrophic sphagnum mosses, must develop before acidophilus sphagnum mosses dominate a Bog. The Bog surface is usually raised or domed, but can sometimes appear flat. Most Bogs on glacial lake plains succeed from sphagnum-dominated Black Spruce Swamps. As these swamps mature, surface water is channeled into areas (drains) that become too wet for black spruce. This results in the formation of nonforested bog fingers that radiate downslope from black spruce crests. These are identifiable on aerial photographs. In the deciduous forest-woodland zone and in small basins in the conifer-hardwood forest zone, open bog communities can succeed Poor Fen. These nonforested bogs are often identifiable by the diversion of surface waters around their perimeters, which causes the formation of characteristic moats.

Because Bogs receive most (if not all) of their water and nutrients from rainfall, the surface water in Bogs is oligotrophic or ombrotrophic. Surface waters are extremely acidic (pH <4.4) with low concentrations of dissolved nutrients (e.g., $[Ca^{2+}] < 2.2$ mg/l). The water table in Bogs is near the surface during the spring but generally falls through the summer. True ombrotrophic bogs, which include raised bogs, can be distinguished from intermediate bogs by their more extreme water chemistry (pH ≤ 4.1, $[Ca^{2+}] \leq 2.2$ mg/l) and their lack of minerotrophic species.

There are two Bog community types, a forested bog and an open (non-forested) bog:

a. tree cover $>30\%$, strongly dominated by black spruce; groundlayer with few or no minerotrophic species (Appendix 4); water chemistry: pH <4.6, $[Ca^{2+}] <6$ mg/l ..... ***Black Spruce Bog***

a. tree cover $<30\%$; groundlayer with few or no minerotrophic species (Appendix 4); water chemistry: pH <4.6, $[Ca^{2+}] <6$ mg/l; often a transitional area between forested bog and fen in patterned peatlands; includes extremely poor fen ..... ***Open Sphagnum Bog***

Black Spruce Bog

Black Spruce Bog occurs mainly in the conifer-hardwood forest zone, and occasionally in the deciduous forest-woodland zone (Fig. 1). Stunted black spruce trees (< 10m tall) dominate the canopy, which may also contain scattered tamaracks. Tree canopy cover is variable but usually greater than 30%. The groundlayer is dominated by ericaceous shrubs (Labrador tea, leatherleaf, swamp laurel, bog-rosemary), the sedge *Carex trisperma*, or the cotton-grass *Eriophorum spissum*. There is a continuous carpet of sphagnum mosses (usually *Sphagnum fuscum* and *S. angustifolium* (recurvum aggregate)), which form hummocks and hollows. Feather mosses (*Pleurozium schreberi*), *Dicranum undulatum*, and *Polytrichum strictum* are abundant at the bases of trees. Plant species that cause this type to differ from Open Sphagnum Bog include lingonberry (*Vaccinium vitis-idaea*), creeping snowberry (*Gaultheria hispidula*), three-leaved-false Solomon's-seal (*Smilacina trifolia*) and the sedge *Carex trisperma*.

Black Spruce Bog is best developed on drier sites--such as the crests and upper slopes of raised bogs--within bog complexes. In these complexes, vigorously growing acidophilus sphagnum mosses prevent most tree reproduction except that of black spruce and tamarack, which can reproduce by layering. Soils in Black Spruce Bogs are composed of deep, highly fibric peat.

Black Spruce Bog commonly grades into Black Spruce Swamp, from which it succeeds, but is distinguishable because it lacks the minerotrophic species present in Black Spruce Swamp (see Appendix 4). Open Sphagnum Bog can develop from Black Spruce Bog when water is channeled onto treed bog slopes and stunts or kills the trees. Although the amount of canopy tree cover may overlap between Black Spruce Bog and Open Sphagnum Bog, the two types can be separated by the abundance of shade-tolerant versus shade-intolerant species present. Distinguishing between these two types is difficult where the tree canopy in a Black Spruce Bog has recently been destroyed by fire or mistletoe.

There are two recognized subtypes of Black Spruce Bog in Minnesota, the Raised Subtype and the Intermediate Subtype. The Raised Subtype occurs only on sites that are genuinely ombrotrophic (rain nourished) with pH < 4.2 and $[Ca^{2+}] \leq 2.2$ mg/l, and it lacks minerotrophic species.

Open Sphagnum Bog

Open Sphagnum Bog occurs mainly in the conifer-hardwood forest zone, with occasional inclusions in the deciduous forest-woodland zone (Fig. 1). Scattered and stunted (less than 10 m tall) black spruce and tamarack may be present, but tree cover is never greater than 30%. The groundlayer is dominated by ericaceous shrubs (leatherleaf, swamp laurel, bog-rosemary), sedges (*Carex* spp.), or cotton grasses (*Eriophorum* spp.). Other characteristic species are round-leafed sundew (*Drosera rotundifolia*) and pitcher plant (*Sarracenia purpurea*). The groundlayer also has a continuous mat of sphagnum mosses, usually dominated by *Sphagnum*

magellanicum or *S. angustifolium*. Species useful in distinguishing Open Sphagnum Bog from Black Spruce Bog are *Carex oligosperma* and *Carex pauciflora*.

Open Sphagnum Bog develops in areas of Black Spruce Bog that become too wet to support black spruce. Although canopy tree cover may overlap between the two bog types, they are separable by differences in the abundance of shade-tolerant versus shade-intolerant species present. Distinguishing between the two types may be difficult where the canopy of a Black Spruce Bog has recently been destroyed by fire or mistletoe. Open Sphagnum Bog also grades into Poor Fen at the bases of raised bogs and in small isolated basins. Species typical of Poor Fens but absent from Open Sphagnum Bogs include *Carex aquatilis*, *C. lasiocarpa*, *C. chordorrhiza*, scheucherzia (*Scheucherzia palustris*), and beaked-sedge (*Rhynchospora alba*).

There are three recognized subtypes of Open Sphagnum Bog in Minnesota, the Raised, Intermediate, and Schlenke Subtypes. These subtypes differ from one-another in water chemistry and water level.

The Raised Subtype occurs only in areas that are genuinely ombrotrophic (receiving nutrients from rainfall only, with pH ≤ 4.1 and $[Ca^{2+}] \leq 2.2$ mg/l) and lacks the minerotrophic species that occur in intermediate bogs. The Intermediate Subtype is not genuinely ombrotrophic, but except for a few minerotrophic indicator species is nearly indistinguishable from "true" raised bogs. The Schlenke Subtype is rare. It occurs only in three raised bogs in Minnesota in which pool formations have developed near the bog crests. The Schlenke Subtype is characterized by maritime bog species such as scheucherzia (*Scheucherzia palustris*), beaked-sedge (*Rhynchospora alba*), and horned bladderwort (*Utricularia cornuta*), and hollows containing *Sphagnum cuspidatum*.

FLOODPLAIN FOREST

Floodplain Forests are wet forests that occur on seasonally-inundated soils along the floodplains of the major rivers in Minnesota, as well as along some perennial streams. Floodplain Forests are especially well developed on floodplains in the Mississippi River, Minnesota River, and Red River valleys. The canopy dominants in Floodplain Forests vary according to the successional status of the stand and the length and duration of annual flooding. The most common canopy dominants are silver maples, cottonwoods, black willows, American elms, green ashes, and bur oaks, which occur either singly or in mixed stands. Black willow and cottonwood are pioneer species, often occurring on sand bars, mud flats, and other areas with recently disturbed soils. Black ash, box elder, hackberry, and basswood are common subdominant canopy species in Floodplain Forests.

The germination and survival of tree and shrub seedlings within Floodplain Forests is severely restricted by flooding. As a result, the understory of most Floodplain Forests is fairly open, with few tree seedlings and saplings or shrubs. Shrubs become important in Floodplain Forests only after persistent disturbance, such as grazing. Woody climbers, including wild grape (*Vitis riparia*), poison ivy (*Rhus radicans*), and Virginia creeper (*Parthenocissus quinquefolia*), are often present in light gaps and along open channels, where they may overgrow trees and contribute significantly to canopy cover. The herb layer has low diversity, and contains only short-lived species or species otherwise tolerant of frequent disturbance. Wild-rye (*Elymus virginicus*), cleavers (*Galium aparine*), sedges (*Carex* spp.), wood nettle (*Laportea canadensis*), and other members of the nettle family (Urticaceae) are common herbaceous species.

The structure and composition of Floodplain Forests is closely related to annual cycles of river flooding and drawdown. Evidence of such cycles includes windrows of debris on the forest floor, ice scars on trees, and abandoned channels that contain water at or above the level of the main river channel. In general, Floodplain Forests in Minnesota have been heavily disturbed by drainage and conversion to agricultural land, logging, channel dredging, and dam construction. In areas where tree canopies are still intact, the ground flora often is altered by human-induced changes in the flood cycle. Box elder is an increasingly common component of Floodplain Forests because of human disturbance, while mature American elms have become much rarer in Floodplain Forests since the introduction of Dutch elm disease to Minnesota.

There is only one recognized Floodplain Forest type in Minnesota:

a. represented by a single type; canopy either 1) dominated by a mixture of black willow, cottonwood, river birch, American elm, slippery elm, green ash, bur oak, or box elder, 2) strongly dominated by silver maple (> 70% cover) with lesser amounts of green ash, black ash, American elm, slippery elm, or hackberry, or 3) dominated by swamp white oak, with lesser amounts of silver maple, green ash, American elm, and bur oak; soils range in texture from silty to sandy ..... ***Floodplain Forest***

Floodplain Forest

Floodplain Forest is a seasonally wet forest community that occurs throughout Minnesota on the active floodplains of major rivers and their tributary streams. The canopy of the community is dominated by deciduous tree species tolerant of inundation, abrasion, and other disturbances associated with flooding. The canopy is variable in composition, either composed of a mixture of tree species or strongly dominated by a single tree species.

The species composition of Floodplain Forests varies both geographically and in relation to such features as substrate type or flood cycles. Along the Red River in northwestern Minnesota, the canopy is generally a mixture of American elms, slippery elms, green ashes, cottonwoods, and bur oaks. Basswoods, box elders, and willows occur less frequently. On smaller northwestern rivers, a mixture of bur oaks, elms, green ashes, and aspens is common, with some areas having only bur oaks. In southern Minnesota, silver maples, black willows, and cottonwoods are common canopy dominants. They occur either in nearly pure stands or in mixed stands. Scattered individuals or patches of river birch, American elm, slippery elm, green ash, and swamp white oak are also common in stands in southern Minnesota. (The geographic variation that occurs among these mixed forests in different parts of Minnesota may be related to differences in substrate and flood regimes among different rivers, however more research is needed.)

The tree canopy cover is highly variable within Floodplain Forests. The canopy is continuous in some stands while other stands have open areas caused by repeated erosion, ice-scouring, and soil and debris deposition, all of which prevent the growth of trees and shrubs. In recent decades, Dutch elm disease has also caused significant canopy openings in Floodplain Forests in which mature American elm trees were abundant in the canopy. Areas beneath tree-canopy openings in the forests are either dominated by short-lived herbaceous plants or, where erosion and disturbance from flooding tend to be repeated and severe, remain unvegetated. The common herbaceous plants in these open patches include those mentioned above in the Floodplain Forest class description.

At present, there are two recognized subtypes of Floodplain Forest, the Silver Maple Subtype and the Swamp White Oak Subtype. (Additional subtypes likely will be recognized as more data on the community become available.) The Silver Maple subtype occurs mainly in the deciduous forest-woodland zone (Fig. 1) along the Minnesota, lower Mississippi, and St. Croix rivers and their tributaries, although there are some stands to the north in the conifer-hardwood forest zone, such as along the Prairie River in Carlton and southern St. Louis counties. The Silver Maple Subtype seems to be best developed in broad, deep glacial meltwater-cut river valleys that have been filling with coarse alluvium ever since the glacial meltwaters subsided. (The Mississippi and St. Croix river valleys are exemplary of these.)

As the name implies, silver maples dominate the tree canopy in this subtype, and are present in the subcanopy and shrub layer as well. Green ashes, cottonwoods, and American elms are often present in the canopy, but are most common as seedlings and saplings. Trees such as hackberry, bur oak, and box elder are sometimes present in the community, but most

often occur only on natural levees along active river channels.

The understory of the Silver Maple Subtype is open, with less than 25% cover by tree seedlings and saplings. Herbs in the nettle family, including wood nettle (*Laportea canadensis*) and clearweed (*Pilea pumila*), dominate the groundlayer. Woody and herbaceous climbers are common, especially wild grape (*Vitis riparia*), wild cucumber (*Echinocystis lobata*), bur-cucumber (*Sicyos angulatus*), groundnut (*Apios americana*), and hog-peanut (*Amphicarpa bracteata*).

The Swamp White Oak Subtype is uncommon in Minnesota, occurring only in the extreme southeastern part of the state on the Mississippi River floodplain and possibly along some smaller rivers. The tree canopy is dominated by swamp white oaks, and generally also contains silver maples, green ashes, American elms, and bur oaks. Upland tree species such as basswood and sugar maple are also present in some stands. Further inventories of stands of the Swamp White Oak Subytpe are needed in order to determine whether its understory species are distinct from those of other floodplain forests.

The Swamp White Oak Subtype is thought to develop primarily on floodplain sites where soil has accumulated or mounded and that are therefore drier than the sites on which most other variants of Floodplain Forest develop. This may be because seedlings of swamp white oak survive most readily in better drained areas. Additionally, mature swamp white oak trees are more fire tolerant than most other floodplain tree species, and these drier floodplain sites may have been more likely to experience fire in the past. The presence of scattered open-grown oak trees in some occurrences of the subtype provide evidence for a previous savanna-like structure, possibly maintained or initiated by fire.

Additional Floodplain Forest subtypes likely will be identified following collection of more data. Divisions probably will be based at least partially on successional status, as Floodplain Forests dominated by black willows and cottonwoods are short-lived, early successional communities that develop on recently disturbed sites, while those dominated by elms, oaks, ashes, and silver maples are longer-lived, later-successional communities with potential for old growth. Geographic sections may also be delineated by watersheds.

HARDWOOD SWAMP FOREST

Hardwood Swamp Forests are minerotrophic wetland communities that occur on muck and shallow peat substrates on wet sites in the deciduous forest-woodland and conifer-hardwood forest zones (Fig. 1). They have tree canopies dominated by broad-leaved deciduous species, including black ash, paper birch, yellow birch, red maple, American elm, slippery elm, green ash, quaking aspen, or, rarely, balsam poplar. Tamarack is sometimes the most abundant tree species present in a stand, but never forms more than 50% of the total tree cover (if so, the swamp is classified as a Tamarack Swamp). White pines or white cedars also occur in the community on occasion. The tree canopy cover ranges from dense (especially in even-aged or drained stands) to sparse, but there is always at least 30% cover by trees over 5 meters tall.

Hardwood Swamp Forests form fairly distinct, often narrow zones at the margins of wetland basins or along streams. They form more extensive stands in shallow, poorly drained depressions or lake basins and in groundwater seepage areas on level terrain at the bases of hills or terrace slopes. Hardwood Swamp Forests often are long-lived communities on nutrient-rich low-disturbance sites. Flooding (especially that caused by beaver dams) and windthrow occasionally kill canopy trees in Hardwood Swamp Forests, causing regression to Shrub Swamps or Wet Meadows. It is usually difficult to identify boundaries between Hardwood Swamp Forests and Shrub Swamps where the two community classes intergrade or form complex patches. Hardwood Swamp Forests also grade into Tamarack Swamp. (Tamaracks tend to dominate Swamp Forests where the organic substrate is poorer in nutrients, thicker, less decomposed, more acidic, or more continuously saturated.)

Hardwood Swamp Forests differ from Floodplain Forests and from Lowland Hardwood Forests by having an organic substrate and continuously or nearly continuously saturated soils during normal years. They also differ from Lowland Hardwood Forests by lacking upland herbs in the groundlayer. Hardwood Swamp Forests and Floodplain Forests may be difficult to separate where low-gradient streams flow across flat lowlands as, for example, along the Rum River on the Anoka Sand Plain in Isanti County.

a. canopy with >50% cover by black ash ..... ***Black Ash Swamp***

a. canopy a mixture of broad-leaved deciduous trees, with <50% cover by black ash .... ***Mixed Hardwood Swamp***

Black Ash Swamp

Black Ash Swamp is dominated by black ash trees, which occur either in almost pure stands or in mixed stands with other hardwoods. Common tree canopy associates include green ashes, paper birches, yellow birches, red maples, and (rarely) bur oaks. In northern Minnesota, white cedars and balsam firs are sometimes present in the canopy. The understory composition

varies considerably and, at present, there are insufficient data to dilineate subtypes of Black Ash Swamp or to give a statewide summary of the community. The descriptions below are for areas in Minnesota for which information is available.

On the Anoka Sand Plain, Black Ash Swamp tends to occur as narrow zones or as small inclusions in wetland complexes. (When black ash occurs in larger swamp areas here, most often it is mixed with other deciduous tree species in Mixed Hardwood Swamps rather than forming Black Ash Swamps). Where the canopy is dense, there are usually few shrubs and the ground cover is dominated by shade-tolerant herbs such as naked bishop's-cap (*Mitella nuda*), lady fern (*Athyrium angustum*), or clearweed (*Pilea pumila*), and bryophytes. Cinnamon fern (*Osmunda cinnamomea*) is sometimes abundant on moderately shady sites. In open, minerotrophic areas the groundlayer is composed of Wet Meadow species, and there is a shrub layer of alder, winterberry, and other species.

In Washington and Chisago counties, very local, small stands of Black Ash Swamp occur in seepage zones at the bases of river terrace slopes; these stands are classified as Seepage Subtypes of Black Ash Swamp. Skunk cabbage (*Symplocarpus foetidus*) and dense tussocks of the fine-bladed sedge, *Carex bromoides* are characteristic in seepage Black Ash Swamps, and the subtype also provides habitat for two rare species, bog bluegrass (*Poa paludigena*) and water-pennywort (*Hydrocotyle americana*). Black Ash Swamp and Mixed Hardwood Swamp are often closely associated and difficult to separate from one-another in these seepage zones.

In eastern St. Louis County, Black Ash Swamp occurs in draws on the Vermillion moraine and the Toimi drumlin field. It also occurs as inclusions in disturbed white cedar stands. On the Aitkin lacustrine plain and elsewhere in St. Louis and Itasca Counties, Black Ash Swamp is floristically similar to White Cedar Swamp, to Shrub Swamps, and to Wet Meadow, communities with which it intergrades. The tree canopy cover ranges from nearly closed (in post-fire, even-aged stands) to open (usually in stands in wetland complexes). Where the tree canopy is open, the understory vegetation is patchy, ranging from open, mixed alder and willow swamps to minerotrophic sedge meadows. Associated tree species include white cedar, red maple, paper birch, balsam fir, and mountain ash, with speckled alder dominant in the shrub layer. Sensitive fern (*Onoclea sensibilis*), northern bugleweed (*Lycopus uniflorus*), common mint (*Mentha arvensis*), and marsh skullcap (*Scutellaria galericulata*) are characteristic herbs. In eastern Marshall County, Black Ash Swamp occurs at the bases of beach-ridge slopes; most likely these sites are areas of groundwater seepage.

At present, there are no recognized sections of Black Ash Swamp. There is one recognized subtype (the Seepage Subtype), which occurs along the St. Croix River and its tributaries in Washington, Chisago, and Pine counties.

Mixed Hardwood Swamp

Mixed Hardwood Swamp is present in the deciduous forest-woodland and conifer-hardwood forest zones (Fig. 1). The community has a mixed canopy of hardwoods, including

paper birches, yellow birches, American elms, black ashes, red maples, quaking aspens, and green ashes. Black ashes, although commonly present, never form more than 50% of the canopy cover in the community. Tamarack or white pine are also occasionally co-dominant canopy tree species. The tree canopy cover ranges from sparse to dense, with the density of the shrub cover varying inversely with the density of the tree canopy.

Mixed Hardwood Swamp occurs most commonly on muck and shallow peat on lake plains and floodplains. It is a long-lived community and has old-growth potential. Like Black Ash Swamp, Mixed Hardwood Swamp varies considerably in its composition across Minnesota. The descriptions below are for specific areas for which information exists.

On the Anoka Sand Plain, Mixed Hardwood Swamp is common in shallow wetlands, especially near upland margins. On sites that are not too wet, Mixed Hardwood Swamp may succeed minerotrophic Alder Swamp. Common canopy dominants on the Sandplain are tamaracks, paper birches, red maples, yellow birches, and black ashes. Occasionally, white pines form a patchy supercanopy above the hardwood canopy. Speckled alders and poison sumacs are the most common shrubs. Other associated species are interrupted fern (*Osmunda claytoniana*), mad-dog skullcap (*Scutellaria lateriflora*), marsh marigold (*Caltha palustris*), the sedge *Carex stipata*, and mosses, including some sphagnum hummocks. Mixed Hardwood Swamps on the Anoka Sandplain harbor two rare plant species, halberd leaved tearthumb (*Polygonum arifolium*) and yellow bartonia (*Bartonia virginica*). Mixed Hardwood Swamp is perhaps the most species-rich community in east-central Minnesota.

A seepage subtype of Mixed Hardwood Swamp occurs in groundwater seepage areas at the bases of terrace slopes near the St. Croix River in Washington, Chisago, and Pine counties. The groundlayer commonly contains skunk cabbage (*Symplocarpus foetidus*) and dense tussocks of the fine-bladed sedge, *Carex bromoides*. Basswood often is present in the tree canopy. The Seepage Subtype is habitat for two rare species, bog bluegrass (*Poa paludigena*) and water-pennywort (*Hydrocotyle americana*).

At present, there are no defined geographic sections of the community.

CONIFER SWAMP FOREST

Conifer Swamp Forests occur mainly in the conifer-hardwood forest zone, but also occasionally in the deciduous forest-woodland zone (Fig. 1). The tree canopy is dominated by black spruces, tamaracks, or white cedars. The density of the shrub, herb, and moss layers varies greatly, depending on the density of the tree canopy, on soil nutrients, and on the level of the water table.

Conifer Swamp Forests tend to develop on sites with wet mineral or poorly drained organic soils. There is often standing or barely moving water within the community. However, the water table usually drops below the tree rooting zone in mid to late summer so the upper soil layers are aerated for at least part of the growing season. Often, Conifer Swamp Forests are associated with springs or seepage areas. The surface waters within Conifer Swamp Forests range from circumneutral to moderately acidic.

White cedars usually grow on nutrient-rich mineral or shallow peat soils in areas protected from fire. Sites with these characteristics are common at the edges of peatlands or along gentle slopes with subsurface groundwater flow. Tamaracks and black spruces occur on nutrient poor-peat soils, with tamaracks tending to occur on the more minerotrophic sites and sites with higher water tables. Black spruces are tolerant of extremely acidic conditions, so Black Spruce Swamp often grades into Black Spruce Bog.

There are three recognized Conifer Swamp Forest community types:

a. canopy mostly white cedar, often with some balsam fir and sometimes with black spruce or tamarack; *Sphagnum* spp. mostly absent ..... ***White Cedar Swamp***

a. canopy not dominated by white cedar; *Sphagnum* spp. present or absent ..... **b.**

b. canopy mostly tamarack, often mixed with paper birch or black ash; groundlayer typically of minerotrophic species (Appendix 4); *Sphagnum* spp. present or absent ..... ***Tamarack Swamp***

b. canopy strongly dominated by black spruce, with minor amounts of tamarack, white cedar, and hardwoods; *Sphagnum* spp. or feathermosses present .... ***Black Spruce Swamp***

White Cedar Swamp

White Cedar Swamp occurs primarily in the conifer-hardwood forest zone, with scattered stands in the deciduous forest-woodland zone (Fig. 1). White cedars dominate the tree canopy, either forming pure, dense, even-aged stands or mixed, uneven-aged stands with various amounts

of black spruces, balsam firs, white spruces, balsam poplars, or black ashes. The shrub layer is composed of speckled alder and associated species. Shrub cover ranges from sparse to dense, depending on the density of the tree canopy. There is usually a layer of mosses in the understory, although mosses tend to be sparse in densely shaded stands.

White Cedar Swamp occurs on wet mineral soils or well-decomposed peat soils on level to gently sloping (<3%) terrain along the margins of peatlands, along drainage courses, and in shallow depressions. White cedar is a fire-sensitive species and consequently tends to grow in moist habitats where the vegetation and litter is rarely dry enough to burn, or in areas protected from fire by topographic breaks. Ecologically, white cedar acts both as a pioneer species, colonizing recently disturbed sites, and as a late-successional species, regenerating in older, closed stands by layering. White cedar is a long-lived tree and therefore White Cedar Swamp forms mature and old-growth stands in the absence of catastrophic disturbance.

There is one subtype of White Cedar Swamp, a Seepage Subtype, which occurs in groundwater seepage areas. Following the completion of studies of old-growth cedar stands, additional subtypes may be defined by nutrient levels, as some stands are very poor in nutrients and have small, very slow-growing cedar trees in comparison with other stands.

Tamarack Swamp

Tamarack Swamp is present throughout the deciduous forest-woodland and conifer-hardwood forest zones (Fig. 1). It occurs on minerotrophic muck and shallow peat along rivers and in shallow lake basins, and on nutrient-poor, mildly-acidic to acidic peat in ice-block basins or large peatland systems. Tamarack is either the only canopy species or is mixed with black spruce, paper birch, yellow birch, white pine, black ash, American elm, or red maple. In minerotrophic wetlands in the deciduous forest-woodland zone, the understory of the community commonly contains speckled alder, winterberry, blue-joint (*Calamagrostis canadensis*), broad-leaved cattail (*Typha latifolia*), and jewel-weed (*Impatiens capensis*). On less minerotrophic sites in the deciduous forest-woodland and conifer-hardwood forest zones, Tamarack Swamp typically has a continuous hummocky mat of sphagnum mosses below such fen associates as bog birch, leatherleaf and other ericaceous species, cinnamon fern (*Osmunda cinnamomea*), wiregrass sedge (*Carex lasiocarpa*), and prairie sedge (*Carex prairea*). In northern Minnesota, tamarack may grow in association with alder, red-osier dogwood, willow species, and mountain fly honeysuckle. The sedge *Carex stricta* is common under relatively open stands of tamarack; cyperus-like sedge (*Carex pseudo-cyperus*) and black chokeberry (*Aronia melanocarpa*) are often present on tear-drop islands in large peatland complexes.

In the absense of catastrophic disturbances, Tamarack Swamps may succeed Shrub Swamps, Rich Fens, Poor Fens, and possibly Hardwood Swamp Forests. Fire, flooding, and insect infestations (e.g., larch sawfly) often reverse this succession. Windthrow, disease, and selective cutting of tamaracks in dense stands help maintain tamarack cover by creating gaps in the canopy in which the very shade-intolerant tamarack seedlings and saplings are able to grow.

Tamarack Swamp differs from Mixed Hardwood Swamp in part by having at least 50% of its canopy cover formed by tamarack. This may not be easy to determine (either from aerial photographs or in the field) because tamaracks are often slender and conical so may be numerous yet still contribute little to the total tree canopy cover. The same problem exists in Shrub Swamps where tamaracks occur as "spires" above the shrub layer. Tamarack Swamp differs from Bog communities in the pH of its surface waters and by having minerotrophic species that do not occur in true bogs (see Appendix 4).

There are three subtypes of Tamarack Swamp, a Minerotrophic Subtype, a Sphagnum Subtype, and a Seepage Subtype. The Seepage Subtype is local and rare. At present, it is documented only along the St. Croix River and along the Sauk River in Stearns County, where it occurs in groundwater seepage areas at the bases of river terrace slopes. The canopy of the seepage subtype is mixed, containing yellow birches, basswoods, and black ashes in addition to tamaracks. There are no geographic sections of Tamarack Swamp although the community may ultimately be divided into northern and southern sections.

Black Spruce Swamp

Black Spruce Swamp occurs primarily in the conifer-hardwood forest zone, with scattered outlying stands in the deciduous forest-woodland zone (Fig 1). The canopy is dominated by black spruces, often growing in pure stands or in association with tamaracks or white cedars. The shrub layer, if present, contains speckled alders. The groundlayer is dominated by sedges (*Carex trisperma*, *C. leptalea*), cotton-grasses (*Eriophorum* spp.), or ericaceous shrubs (labrador tea, bog-rosemary, swamp laurel, creeping snowberry). The moss layer is usually continuous, with feathermosses predominant, although they may be mixed with minerotrophic *Sphagnum* species.

Black Spruce Swamp occurs on shallow to deep, moderately acidic peat. Nutrient levels in the community vary with the depth and degree of decomposition of the peat. Under certain conditions, Black Spruce Swamps will succeed to Black Spruce Bogs, as the surface waters in the community become acidified and there is an increase in the abundance of peat-forming sphagnum mosses. Black Spruce Swamp differs from Black Spruce Bog by containing species that grow in minerotrophic environments (see Appendix 4). Black spruce is long-lived in swamps or bogs, and may form mature and old-growth stands.

There are no subtypes of Black Spruce Swamp in this classification. The following subtypes appear in the literature on boreal forests: black spruce-sphagnum, black spruce-alder, black spruce-herb, black spruce-sedge, black spruce-half shrub, and black spruce-seepage.

SHRUB SWAMP

Shrub Swamps are minerotrophic, tall-shrub communities, most often present on mucks and shallow peat in the deciduous forest-woodland and conifer-hardwood forest zones (Fig. 1). The major shrub species in these communities are speckled alder, willows (especially pussy willow, slender willow, and Bebb's willow), and red-osier dogwood. The shrub canopy ranges from interrupted, with many light gaps, to closed, with the ground well shaded below. Graminoid-dominated openings, if present, are not distinctly separated from shrub clumps. Poison sumac or alder buckthorn often dominate the canopy in disturbed swamps in east-central Minnesota.

Shrub Swamps are considered mid-successional communities, between Wet Meadow/Fen communities and Conifer or Hardwood Swamp Forests. However, Shrub Swamp communities are relatively stable in areas where water table fluctuations are small, as the loss or gain of woody vegetation in many wetland areas is linked to particularly dry or wet cycles that affect seedling establishment, flooding, windthrow, and fire frequency. Before European settlement, extensive areas of Shrub Swamp existed in shallow wetlands on outwash plains and in glacial lake basins. Where fires occurred relatively frequently in wetland areas, the wetland communities probably were open, mainly lacking shrubs or trees. Occasional fires or prolonged flooding (such as from beaver ponds) in Conifer Swamp or Hardwood Swamp may have been important in maintaining patches of Shrub Swamp in areas that are predominantly swamp forest. Artificially drained meadows or fens rapidly succeed to shrubby Wet Meadow or Fen, to Shrub Swamp, or to forested swamps.

Two Shrub Swamp community types exist in Minnesota, Alder Swamp and Willow Swamp. These two types are similar to alder thicket and shrub-carr communities described in other classifications.

a. speckled alder is the most abundant shrub species in the canopy although the combined cover of willows, dogwood, poison sumac or other canopy shrubs may exceed the cover of alder ....***Alder Swamp***

a. willows or red-osier dogwood are the most abundant shrub species in the canopy; speckled alder may be present but is not the single most abundant shrub species ..... ***Willow Swamp***

Alder Swamp

Alder Swamp is a minerotrophic wetland with a canopy of tall shrubs dominated by speckled alder, often mixed with other shrub species such as willows, bog birch, poison sumac, or alder buckthorn. Common understory species in the community are tussock sedge (*Carex stricta*), prairie sedge (*Carex prairea*), lake-bank sedge (*Carex lacustris*), broad-leaved cattail (*Typha latifolia*), blue-joint (*Calamagrostis canadensis*), northern marsh fern (*Thelypteris*

palustris), jewel-weed (*Impatiens capensis*), and *Sphagnum squarrosum*. The shrub canopy is usually continuous and dense, but may be interrupted, especially as a result of flooding. The understory graminoid cover tends to be sparse wherever the shrub canopy is especially dense. Graminoid-dominated openings are not distinctly separated from shrub clumps as in Wet Meadow or Fen communities. Trees, including northern white cedars, tamaracks, black ashes, and paper birches, are occasionally present in Alder Swamps, but have less than 30% cover.

There are no recognized subtypes or sections of Alder Swamp.

Willow Swamp

Willow Swamp is a minerotrophic wetland with a canopy of medium to tall (>1m) shrubs dominated by willows (especially pussy willow, slender willow, and Bebb's willow) and red-osier dogwood. Other shrubs, such as speckled alder, bog birch, poison sumac, and alder buckthorn, may be common in the tall shrub layer, although speckled alder is never the most abundant species present. Herbaceous species (especially graminoids) characteristic of Wet Meadow/Fen communities are common in the more open occurrences of the community. However, in Willow Swamps, unlike Wet Meadow/Fen communities, these graminoid-dominated patches are poorly separated from clumps of shrubs. The most common herbs are tussock sedge (*Carex stricta*), prairie sedge (*Carex prairea*), lake-bank sedge (*Carex lacustris*), broad-leaved cattail (*Typha latifolia*), blue-joint (*Calamagrostis canadensis*), northern marsh fern (*Thelypteris palustris*), and jewel-weed (*Impatiens capensis*).

Willow Swamps dominated by bog birch are closely related to the Shrub Subtype of Rich Fen but have more minerotrophic indicator species (see Appendix 4) than are present in Rich Fens. Following fire in Conifer Swamps or in the Shrub Subtype of Rich Fens there may be initially a dense cover of willows (usually balsam willow and bog willow), but these stands are best classified as successional stages of Conifer Swamp or Rich Fen rather than as Willow Swamp. The dense groves of sand-bar willow or juvenile black willow that occur on sand bars along rivers are not considered Shrub Swamp communities but instead River Beach communities, as they occur on mineral rather than peat or muck substrates.

At present, there are no recognized or proposed sections or subtypes of Willow Swamp.

EMERGENT MARSH

Emergent Marshes are shallow-basin wetlands that have standing water present during most of the year. They occur throughout Minnesota, typically in association with lakes, ponds, and streams. Marsh bottoms have mineral soils or relatively inorganic sediments, although marshes dominated by cattails often contain floating, peaty mats. Marsh vegetation is composed of tall, erect, rooted herbaceous hydrophytes (Appendix 4) that are present for most of the growing season during years of normal rainfall. Emergent marshes often have zones of vegetation related to soil or sediment type, to the depth and permanence of standing water, and to groundwater influence. The dominant emergent species in marshes are usually graminoids such as cattails (*Typha latifolia* and *T. angustifolia*), common reed grass (*Phragmites australis*), bulrushes (*Scirpus* spp.), rushes (*Juncus* spp.), spike-rushes (*Eleocharis* spp.), and some umbrella sedges (*Cyperus* spp.). Common herbs associated with the emergent graminoids are broad-leaved arrowhead (*Sagittaria latifolia*), swamp milkweed (*Asclepias incarnata*), willow-herbs (*Epilobium* spp.), bulb-bearing water-hemlock (*Cicuta bulbifera*), and several species of *Polygonum*. Obligate aquatic plants (including *Potamogeton*, *Elodea*, *Ceratophyllum*, and *Myriophyllum*) often are present at the bases of the emergent species. The Emergent Marsh community class includes wetland types 3 and 4 as described in Fish & Wildlife Service Circular 39.

Emergent Marsh communities are stable, and do not necessarily need frequent disturbance in order to persist at a site. Invasion by woody species may cause succession of Emergent Marshes to Shrub Swamp, but this process is slow and fires during severe drought years are believed to further retard the spread of woody vegetation. Additionally, marshes are generally too wet for most woody plants to survive, as these plants lack the adaptations common to emergent aquatic plants for distributing oxygen to roots during long periods of inundation and anoxia.

Nonpersistent emergent wetlands (those in which plants are below the surface of the water or below the soil for part of the year) are not included in this class but are treated as aquatic communities. Nonpersistent wetlands include those dominated by pond-lilies (*Nuphar* spp.), water-lilies (*Nymphaea* spp.), pickerel-weed (*Pontederia cordata*), wild rice (*Zizania aquatica*), and other nonpersistent aquatic species.

There are two recognized Emergent Marsh community types:

a. cover mostly cattails ..... ***Cattail Marsh***

a. cover mostly a mixture of bulrushes, common reed grass, and graminoids other than cattails ..... ***Mixed Emergent Marsh***

Cattail Marsh

Cattail Marsh is an emergent marsh dominated by cattails (including *Typha angustifolia*, *T. latifolia*, and their hybrids). It occurs most commonly along lake margins and in shallow basins, although it is sometimes also present in river backwaters. Lacustrine cattail marshes typically have a muck-bottom zone bordering the shoreline, where cattails are rooted in the bottom substrate, and a floating mat zone, where the roots do not contact the bottom but instead the plants grow suspended in a buoyant peaty mat. Associated species vary widely, but some of the most common ones are sedges of the genus *Carex* (*C. aquatilis*, *C. rostrata*, and *C. lanuginosa*), bulrushes (*Scirpus americanus*, *S. acutus*, and *S. heterochaetus*), and broad-leaved herbs such as northern marsh fern (*Thelypteris palustris*), swamp milkweed (*Asclepias incarnata*), jewel-weed (*Impatiens capensis*), broad-leaved arrowhead (*Sagittaria latifolia*), mad-dog skullcap (*Scutellaria lateriflora*), marsh skullcap (*Scutellaria galericulata*), and blue vervain (*Verbena hastata*).

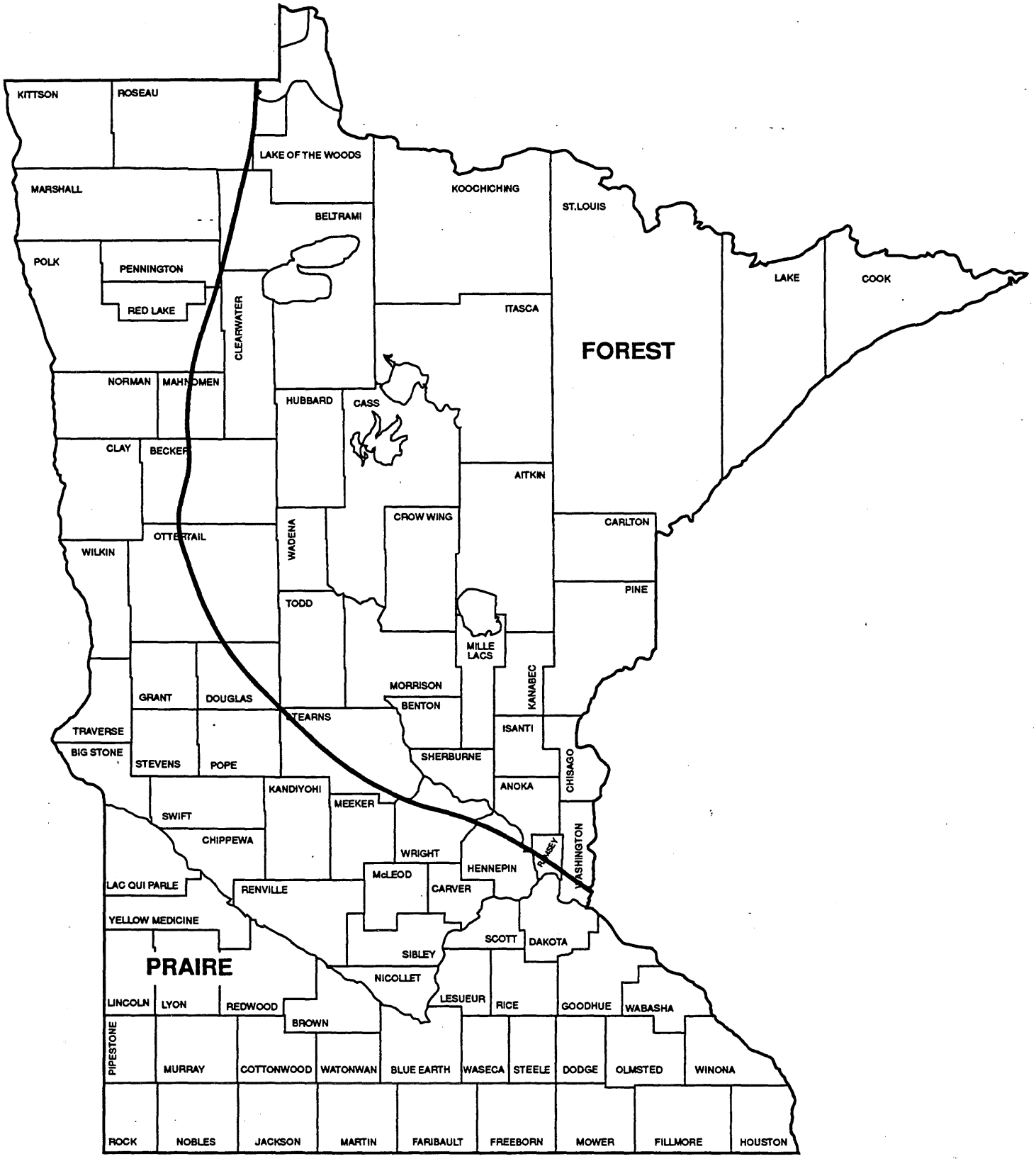
There are no recognized sections or subtypes of Cattail Marsh.

Mixed Emergent Marsh

Mixed emergent marsh is dominated by wetland species other than cattails. Bulrushes are the most common dominants, especially hard-stemmed bulrush (*Scirpus acutus*), river bulrush (*Scirpus fluviatilis*), softstem bulrush (*Scirpus validis*), *Scirpus americanus*, and *Scirpus heterochaetus*. Common reed grass (*Phragmites australis*), spike rushes (*Eleocharis* spp.), and (in some river backwaters) prairie cordgrass (*Spartina pectinata*) are less common dominants. In general, Mixed Emergent Marsh tends to occur on harder pond, lake, or river bottoms than Cattail Marsh and is less likely to contain the forbs that grow on the floating peat mats present in many cattail marshes. Broad-leaved arrowhead (*Sagittaria latifolia*) and aquatic macrophytes are the most common non-graminoid associates. Many Mixed Emergent Marsh species are sensitive to fertilizer run-off and other artificial disturbances, and disturbed Mixed Emergent Marshes (especially in the Prairie Zone) tend to convert to Cattail Marshes or become strongly dominated by reed canary grass (*Phalaris arundinacea*) or common reed grass (*Phragmites australis*), species that increase in abundance with disturbance.

Mixed Emergent Marsh is a broad community type, encompassing all marshes dominated by species other than cattails. Therefore, subtyping or recognition of new marsh types is likely following more thorough inventories of these marshes. New divisions most likely will be made according to dominant species or basin types (e.g., lacustrine versus riverine), or both. There are two geographic sections, a Forest Section and a Prairie Section (Fig. 16). The dominant species in the Prairie Section tend to have a Great Plains distribution while those in the Forest Section tend to have a Great Lakes distribution.

Figure 16. The Forest and Prairie Sections of Mixed Emergent Marsh.



WET MEADOW/FEN

Wet Meadow/Fen is a broad class of community types whose main shared characteristic is a closed canopy of mid-height graminoids. Dominant species include grasses (e.g., bluejoint (*Calamagrostis canadensis*, prairie cordgrass (*Spartina pectinata*)), sedges (eg., wiregrass sedge (*Carex lasiocarpa*), lake-bank sedge (*Carex lacustris*), tussock sedge (*Carex stricta*)), and rushes (e.g., *Scirpus cespitosa*). Although there may be significant shrub cover, especially from willow species and bog birch, a continuous matrix of graminoid species in the understory differentiates the communities of this class from Shrub Swamp communities. Obligate aquatic species (Appendix 5) are mostly absent, however facultative aquatic species are often present in the subcanopy. Mosses are present in some of the Wet Meadow/Fen community types, but sphagnum mosses are absent or have low cover compared with other (Amblystegiaceae) mosses.

Wet Meadow/Fen community types occur on wet mineral or peat soils with seasonally standing or flowing water at the ground surface. Generally, they occur on sites too wet for significant invasion by woody species or on sites that burn frequently.

Seven Wet Meadow/Fen community types are recognized in Minnesota:

a. groundlayer dominated by prairie grasses and forbs ..... **b.**

b. shrub cover >30% ..... ***Wet Brush-Prairie***

b. shrub cover <30% ..... ***Wet Prairie***

a. groundlayer dominated by wetland graminoids or half-shrubs rather than prairie grasses and forbs ..... **c.**

c. groundlayer dominated by narrow-leaved graminoids (leaves narrower than 3mm), especially wiregrass sedge (*Carex lasiocarpa*); forb cover and diversity low; peat depth generally >0.5m; lateral movement of groundwater often visible or inferable from vegetation patterns (e.g. teardrop islands or strings) or from species associated with groundwater movement (e.g., grass of Parnassus (*Parnassia* spp.), *Scirpus cespitosus*) ..... **FENS .... d.**

d. sphagnum cover interrupted to continuous; groundlayer of weakly minerotrophic species (Appendix 4), pH <5.9, [Ca^{2+}] <13 mg/l ..... ***Poor Fen***

d. sphagnum cover patchy to absent; groundlayer of minerotrophic to highly minerotrophic species (Appendix 4), pH >5.9, [Ca^{2+}] >10 mg/l ..... **e.**

e. source of water from springs or zones of discharge; springs or spring features evident; water with circumneutral to high pH; groundlayer often composed of species associated with soils high in dissolved (especially

Ca^{2+}-conataining) salts (Appendix 4) ..... ***Calcareous Seepage Fen***

e. source of water not obviously springs; spring features and surface-flow features absent; groundlayer composed of minerotrophic to highly minerotrophic species (Appendix 4) .....***Rich Fen***

c. groundlayer dominated by wide-leaved graminoids (leaves wider than 3mm), especially lake-bank sedge (*Carex lacustris*), tussock sedge (*Carex stricta*), and bluejoint (*Calamagrostis canadensis*); forb cover diverse; peat depth generally <0.5m ..... **f.**

f. groundwater generally stagnant or, if flowing, flow is weak and not concentrated in obvious rivulets or streams; water generally at or near air temperature ..... ***Wet Meadow***

f. groundwater moving, rivulets and spring heads or obvious zones of groundwater discharge present; water cold; forb cover high where skunk cabbage (*Symplocarpus foetidus*) and angelica (*Angelica atropurpurea*) are present .... ***Seepage Meadow***

Wet Brush-Prairie

Wet Brush-Prairie is an open wetland community of the northern part of the deciduous forest-woodland zone (Fig. 1). It is composed of clumps or thickets of low brush in a herbaceous matrix dominated by grasses characteristic of Wet Prairie. Some of the most important grasses in the community are prairie cordgrass (*Spartina pectinata*), bog reed-grass (*Calamagrostis inexpansa*), blue-joint (*Calamagrostis canadensis*), big bluestem (*Andropogon gerardii*), and mat muhly (*Muhlenbergia richardsonis*). Wheatgrass (*Agropyron trachycaulum*), prairie dropseed (*Sporobolus heterolepis*), fowl meadowgrass (*Poa palustris*), hair grass (*Deschamsia cespitosa*), and switchgrass (*Panicum virgatum*) are also common. *Carex lanuginosa*, *C. sartwellii*, *C. buxbaumii*, and *C. tetanica* are common sedge species in the community.

Forbs are moderately abundant in most Wet Brush-Prairies. The forbs present in the community are generally those also present in Wet Prairie. Brush height is usually less than 1.5 meters, and brush cover is generally 30 to 50 percent. Willows (mainly pussy and slender willows) are the principal brush species. Bog birch and meadowsweet are also important on some sites. Shrubby cinquefoil is less common. Wet Brush-Prairies also commonly contain thickets of quaking aspen and balsam poplar saplings, or even scattered groves of aspen and poplar trees. Wet Brush-Prairie appears to extend farther southward in the Glacial Lake Agassiz Interbeach Area (Fig. 14) than Mesic Brush Prairie.

Wet Brush-Prairie is a fire-dependent community. Tracts of Wet Brush-Prairie that do not burn frequently enough succeed to Aspen Woodland. Infrequent fire can actually promote

increased aspen cover in Brush-Prairie as heat from fire stimulates aspen suckering. The tree cover in most areas of Wet Brush-Prairie appears to be greater now than that indicated by early public land surveyors (ca. 1850-1900), probably because of the effective suppression of wildfires in Minnesota since that period.

Soils in Wet Brush-Prairie range in texture from loamy fine sand to sandy clay loam and are poorly drained to very poorly drained. Most soils are mollisols but entisols are also present in the community. Most often, the soils are calcareous. On level terrain in extreme northwestern Minnesota, Wet Brush-Prairie occurs in a mosaic with Mesic Brush-Prairie and brushy Wet Meadow. These communities are not well separated floristically. Southward, the shrub species become more clumped and better separated from the prairie species, and Wet Brush-Prairie grades into Wet Prairie. Wet Brush-Prairie grades into Aspen Openings where aspen cover increases in the community relative to prairie cover.

There is one subtype of Wet Brush-Prairie, a Seepage Subtype. There are no geographic sections.

Wet Prairie

Wet prairie occurs mainly in the southern and western parts of the prairie zone, with scattered occurrences in the deciduous forest-woodland zone (Fig. 1). Typically, Wet Prairie is dominated by grasses, but sedges are also important in the community. The major cover-forming grasses in wet prairies in eastern Minnesota are prairie cordgrass (*Spartina pectinata*) and blue-joint (*Calamagrostis canadensis*). Prairie cordgrass and blue-joint are also present in Wet Prairies in western Minnesota, but the major cover-forming grasses in the west are bog reed-grass (*Calamagrostis inexpansa*), big bluestem (*Andropogon gerardii*), and the low grass, mat muhly (*Muhlenbergia richardsonis*). Other common grasses in the community are switchgrass (*Panicum virgatum*), wheatgrass (*Agropyron trachycaulum*), fowl meadow grass (*Poa palustris*), and sweet grass (*Hierocloe odorata*). The introduced grass redtop (*Agrostis stolonifera*) is often present on disturbed sites. Common Wet Prairie sedges are *Carex lanuginosa*, *C. sartwellii*, *C. tetanica*, and, in the west, *C. praegracilis*. Stiff rush (*Juncus balticus*) is frequently present.

Forbs are abundant in Wet Prairies, but on the whole fewer forb species occur in Wet Prairie than in Mesic Prairie. Common widespread Wet Prairie forb species are panicled aster (*Aster lanceolatus*), New England aster (*A. novae-angliae*), meadow ragwort (*Senecio pseudaureus*), giant goldenrod (*Solidago gigantea*), Riddell's goldenrod (*S. riddellii*), giant sunflower (*Helianthus giganteus*), sawtooth sunflower (*H. grosseserratus*), sneezeweed (*Helenium autumnale*), gay-feather (*Liatris pycnostachya*), blazing-star (*L. ligulistylis*), grass-leaved goldenrod (*Euthamia graminifolia*), Indian hemp (*Apocynum sibiricum*), golden alexanders (*Zizia aurea*), closed gentian (*Gentiana andrewsii*), yellow star-grass (*Hypoxis hirsuta*), marsh vetchling (*Lathyrus palustris*), tall meadow rue (*Thalictrum dasycarpum*), prairie loosestrife (*Lysimachia quadriflora*), Virginia mountain-mint (*Pycnanthemum virginianum*), swamp lousewort (*Pedicularis lanceolata*), and northern bog violet (*Viola neprophylla*). Small willows (pussy willow and other willow species) and meadowsweet are common in the community;

willow and aspen trees are also sometimes present, growing either singly or scattered in small clumps along wetland margins.

Wet Prairie is a fire-dependent community, with shrub and tree cover increasing in the community in the absense of fire (lthough regular haying will also prevent increased shrub and tree cover in the community.) Wet Prairie occurs in low areas (such as depressions and drainageways) where the water table remains within the plant rooting zone for several weeks during the growing season, but where inundation occurs only infrequently and briefly. In some Wet Prairies groundwater seepage causes soils to be very moist or wet. Wet Prairie is especially common on broad, poorly drained flats in the Glacial Lake Agassiz Interbeach Area (Fig. 14), where there are many areas of artesian seepage. In the deciduous forest-woodland zone, Wet Prairie exists on broad, nearly level river terraces or in shallow depressions on outwash.

The soils within the community are mainly mollisols (aquolls). They range in texture from silty clays to fine sands and are somewhat poorly drained to very poorly drained. Impermeable subsurface layers impede soil drainage on some sites, and a thin layer of muck may be present at the ground surface on Wet Prairies in seepage areas. Most soils are calcareous. Salt concentrations (sulfates of calcium and magnesium) high enough to influence the species composition of the community are present in the soils of Wet Prairies along the western edge of Minnesota, primarily in the Agassiz Lacustrine Plain.

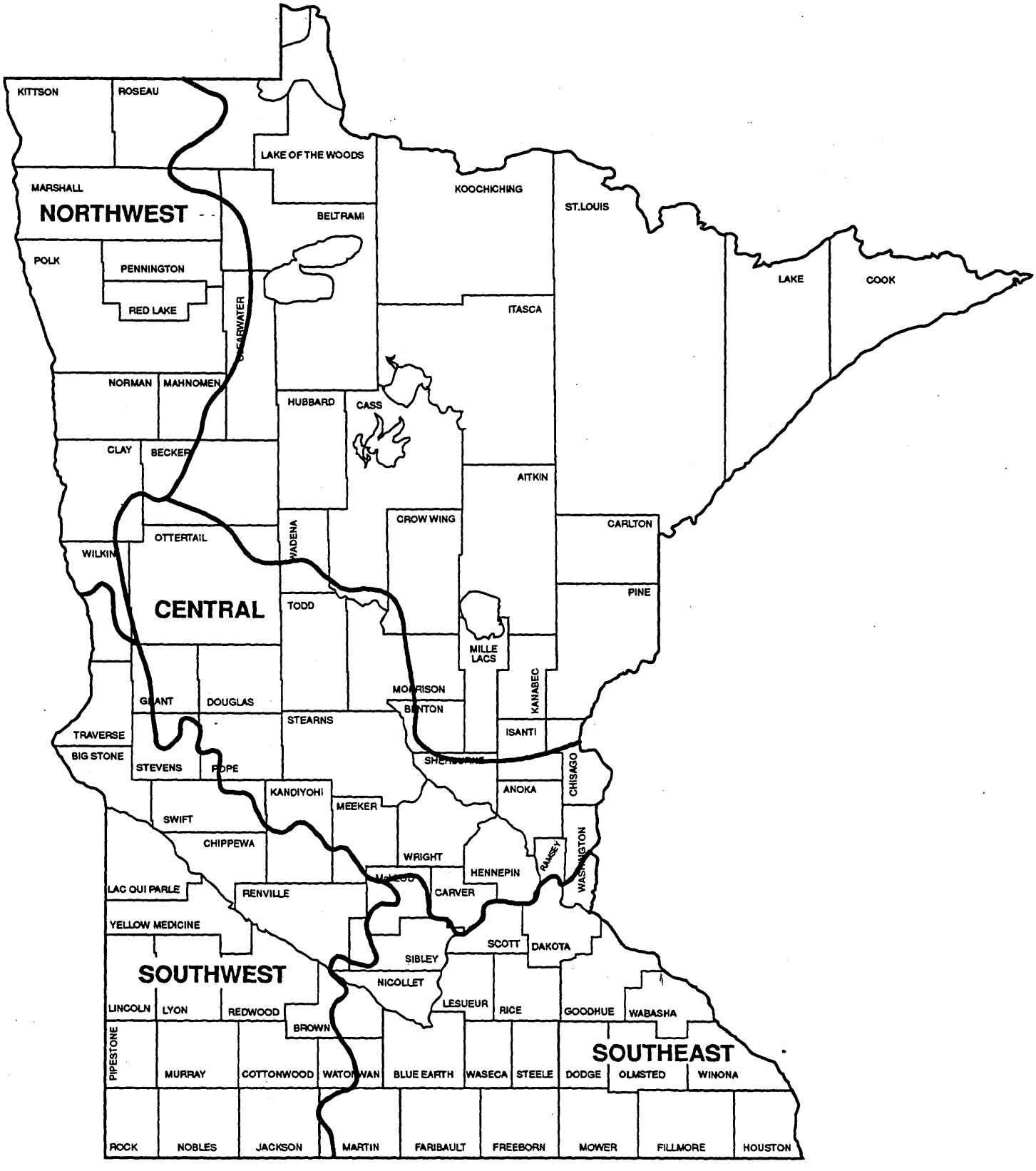
On drier sites Wet Prairie often grades into wet-mesic stands of Mesic Prairie; on wet sites it often grades into Wet Meadow. Mesic Prairie, Wet Prairie, and Wet Meadow do not have well-defined floristic boundaries, and sometimes are difficult to separate from one-another in the field when they occur together. Shrub cover increases in Wet Prairie northward, and in the northern part of the community's range Wet Prairie often grades into Wet Brush-Prairie. Wet Prairie in southeastern Minnesota is distinctive from that elsewhere in the state, containing several species with restricted distribution. Floristic diversity is low in Wet Prairies in western Minnesota, but distinctive species assemblages occur there in association with saline sites.

The regional variation described above is the basis for delineation of four geographic sections of Wet Prairie (Southeast, Southwest, Central, and Northwest, Fig. 17). There are also two recognized subtypes, a Saline Subtype and a Seepage Subtype. Occurrences of the Seepage Subtype almost always have significant shrub cover (especially by bog birch). Further data collection and analysis may reveal that these seepage occurrences are actually Wet Brush Prairie rather than Wet Prairie. Revision of the existing sections and recognition of additional subtypes on the basis of soil properties is possible, following collection and analysis of plot data.

Poor Fen

Poor Fen is most common in the conifer-hardwood forest zone, with scattered occurrences in the deciduous forest-woodland zone (Fig. 1). The ground cover of the community is dominated by wiregrass sedge (*Carex lasiocarpa*) or few-seeded sedge (*C. oligosperma*). Mud sedge (*C. limosa*), creeping sedge (*C. chordorrhiza*), beaked-sedge

Figure 17. The Southeast, Southwest, Central, and Northwest Sections of Wet Prairie.



(*Rhynchospora alba*), tufted club-rush (*Scirpus cespitosus*), scheuchzeria (*Scheuchzeria palustris*), and ericaceous shrubs are present in most Poor Fens as associates of the dominant sedges. Poor Fens have at least 50% cover by sphagnum mosses, and up to 70% cover by shrubs and small trees, most commonly bog birches and stunted tamaracks.

Poor Fen occurs on deep peat (> 1.0m) that receives minimal nutrient-rich run-off from surrounding uplands. In Minnesota's large patterned peatlands, Poor Fen often is present on sites with water infiltration from adjacent raised bogs. Less frequently, Poor Fen occurs in the interiors of small basins that are relatively isolated from run-off. The surface water of Poor Fen is slightly acidic (pH 4.1 - 5.9) and nutrient poor ($[Ca^{2+}] < 13$ mg/l). Poor Fen is transitional between Rich Fen and Open Bog and commonly grades into these communities on the landscape.

There are three subtypes of Poor Fen, a Sedge Subtype, a Shrub Subtype, and a Scrub Tamarack Subtype.

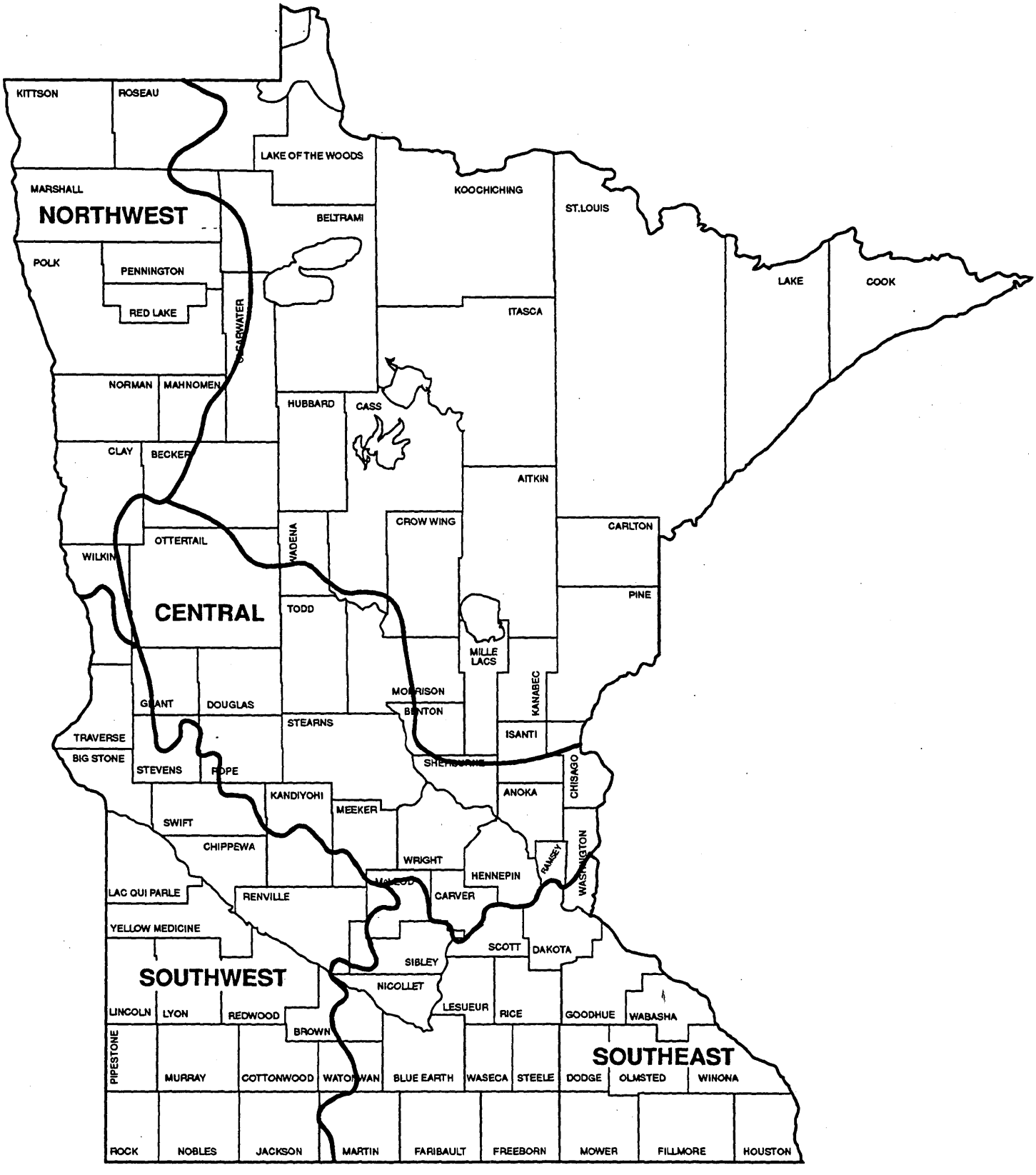
Calcareous Seepage Fen

Calcareous Seepage Fen is an open sedge and rush community that occurs throughout Minnesota. The groundlayer is usually dominated by wiregrass sedge (*Carex lasiocarpa*), *Carex sterilis*, beaked-sedge (*Rhynchospora capillacea*), spike-rush (*Eleocharis rostellata*), and *Scirpus cespitosus*. Marsh muhly (*Muhlenbergia glomerata*), grass of Parnassus (*Parnassia glauca*) and Kalm's lobelia (*Lobelia kalmii*) are often present in Calcareous Seepage Fens (as well as in Rich Fens). Shrubs, including bog birch, sage-leaved willow, and shrubby cinquefoil, are common in the community. Mosses range in cover from abundant to scarce.

Calcareous Seepage Fens occur on shallow or deep peaty soils in areas of calcareous groundwater discharge. The surface water is usually circumneutral (pH 6.8 - 8.0) with high concentrations of dissolved salts ($[Ca^{2+}]$ = 10-100 mg/l) that often form a visible marl precipitate. The discharge water is low in oxygen (anoxic), which is believed to be important in inhibiting dense vegetation growth, thereby promoting the occurrence of several rare heliophytic vascular and bryophyte plant species in the community.

There are two subtypes of Calcareous Seepage Fen, a Prairie Subtype and a Boreal Subtype. The Prairie Subtype (which occurs in both the prairie and deciduous forest-woodland zones (Fig. 1)) contains many characteristically prairie species, including big bluestem (*Andropogon gerardi*), yellow stargrass (*Hypoxis hirsuta*), Virginia mountain-mint (*Pycnanthemum virginianum*), starry false Solomon's-seal (*Smilacina stellata*), and golden alexanders (*Zizia aurea*). The Prairie Subtype also commonly contains patches of emergent aquatic species such as broad-leaved cattail (*Typha latifoliay*, hard-stemmed bulrush (*Scirpus acutus*), *Scirpus americanus*), and common reed grass (*Phragmites australis*). The Prairie Subtype is divided into three geographic sections, a Southeast Section, a Southwest Section, and a Northwest Section (Fig. 18). The Boreal Subtype occurs in the Conifer-Hardwood Forest Zone and contains species characteristic of high-boreal peatlands, including bog-rosemary (*Andromeda glaucophylla*), small cranberry (*Vaccinium oxycoccos*), and pitcher plant (*Sarracenia*

Figure 18. The Southeast, Southwest, and Northwest Sections of Calcareous Seepage Fen, Prairie Subtype.



purpurea). The Boreal Subtype has no recognized geographic sections.

Rich Fen

Rich Fen occurs in the conifer-hardwood forest and deciduous forest-woodland zones (Fig. 1). The groundlayer is dominated by wiregrass sedge (*Carex lasiocarpa*), brown sedge (*Carex buxbaumii*), livid sedge (*Carex livida*), *Calamagrostis neglecta*, or bog reed-grass (*Calamagrostis inexpansa*). Although generally open communities, Rich Fens may have up to 70% cover of woody shrubs, especially bog birches, sage-leaved willows, and shrubby cinquefoils. Mosses range from scarce to abundant in the community. Where mosses are abundant, the dominant species are species other than *Sphagnum* spp.

Surface waters within the community are slightly acidic to circumneutral (pH 5.8 - 7.8) with moderate nutrient levels ($[Ca^{2+}]$ = 10-32 mg/l). Rich Fen grades into Poor Fen but is distinguishable from Poor Fen by its higher species diversity and by the more frequent occurrence and greater abundance of minerotrophic indicator species, including livid sedge (*Carex livida*), brown sedge (*C. buxbaumii*), swamp lousewort (*Pedicularis lanceolata*), spike-rush (*Eleocharis compressa*), marsh muhly (*Muhlenbergia glomerata*), and Kalm's lobelia (*Lobelia kalmii*).

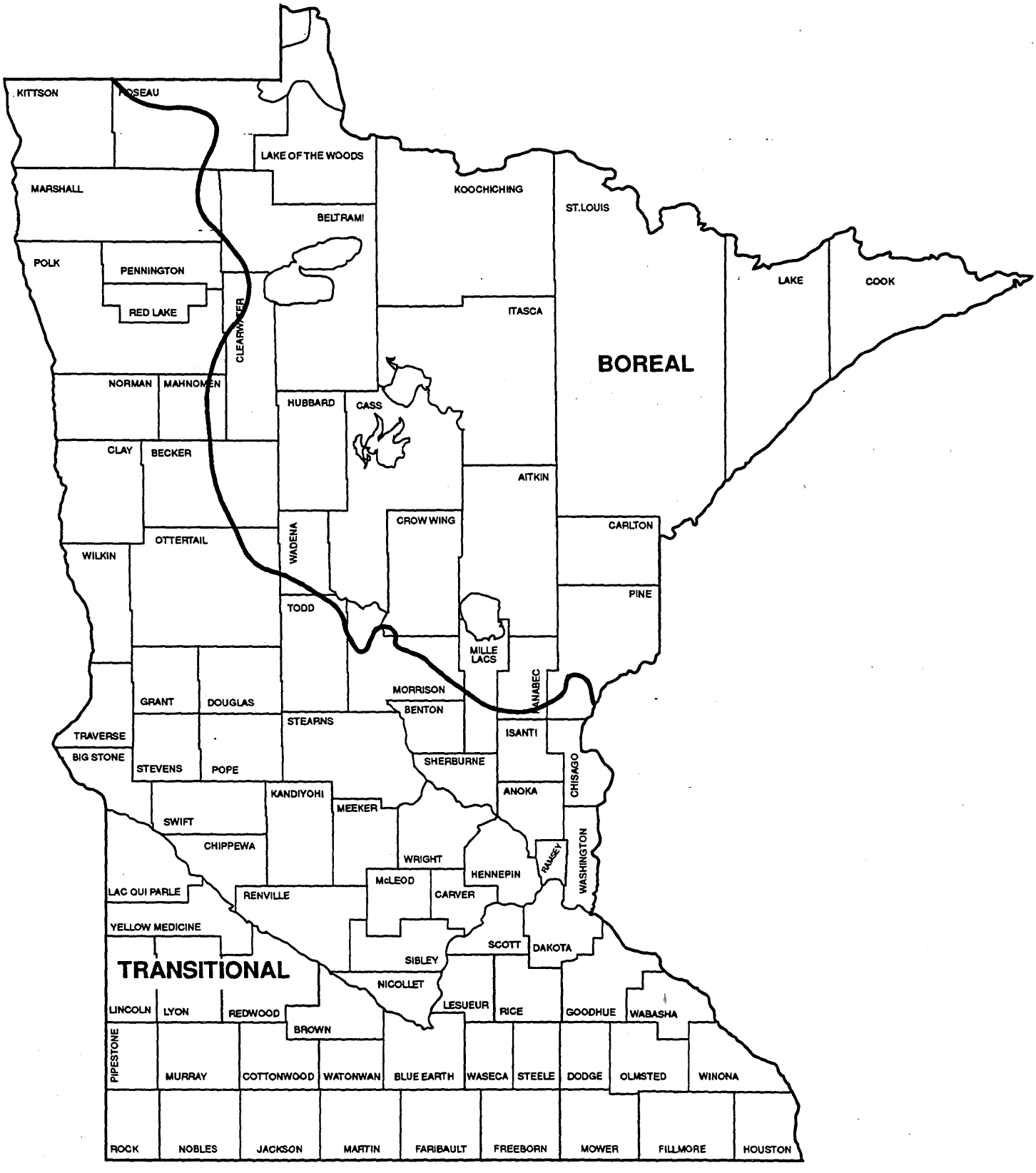
There are two geograpic sections of Rich Fen, a Transition Section and a Boreal Section (Fig 19). In the Boreal Section, Rich Fen usually occurs on deep peat and contains characteristically northern species such as bog-rosemary (*Andromeda glaucophylla*) and othe ericaceous shrubs, the bulrush *Scirpus hudsonianus*, and pitcher-plant (*Sarracenia purpurea*). In the Transition Section Rich Fen may be present on relatively shallow peat, or on very shallow, highly decomposed, low-buoyancy peat, or even on wet mineral soil. Floristically, Rich Fen in the Transition Section differs from Rich Fen in the Boreal Section mainly by containing prairie species, such as grass-leaved goldenrod (*Euthamia graminifolia*), Sartwell's sedge (*Carex sartwellii*), and wooly sedge (*C. lanuginosa*).

The Boreal and Transition Sections of Rich Fen each contain three subtypes, a Sedge Subtype, in which sedges are the dominant plant species, a Floating-Mat Subtype, in which the community occurs on floating peat mats along the margins of shallow lakes, and a Shrub Subtype, in which shrubs are among the dominant plant species (with up to 70% cover.)

Wet Meadow

Wet Meadow is present throughout Minnesota. The groundlayer of the community is composed of dense, closed stands of predominately wide-leaved sedges (eg., *Carex lacustris*, *C. stricta*, *C. aquatilis C. rostrata*, *C. haydenii*) or grasses (eg., *Calamagrostis canadensis*, *C. inexpansa*). Forb cover and diversity usually are high. Forbs such as spotted joe-pye weed (*Eupatorium maculatum*), common mint (*Mentha arvensis*), turtlehead (*Chelone glabra*), and swamp milkweed (*Asclepias incarnata*) are conspicuous. Shrub cover in Wet Meadows ranges

Figure 19. The Transition and Boreal Sections of Rich Fen.



from 0 to 70% and is composed of Bebb's willows and pussy willows. Mosses are rare or absent.

Wet Meadow occurs on wet mineral soil, muck, or shallow peat (<0.5 m). Standing water (generally stagnant) is present in the spring and after heavy rains, but the water table is generally below the soil surface for most of the growing season. The drawdown of the water table as the growing season progresses enables the oxidation of dead organic matter that has accumulated on the ground surface from previous years. This process makes available nutrients for some of the nutrient-demanding species present in the community. Occurrences of Wet Meadow along stream courses or adjacent to lakes often have fairly constant water levels relative to Wet Meadows in depressions or basins. On these sites siltation may be important in maintaining high nutrient levels.

Wet Meadow tends to succeed to Shrub Swamp communities in the absence of fire. Water-table lowering caused by drought or by ditching promotes succession of Wet Meadow to Shrub Swamps. Wet Meadows on organic soils, like other communities that occur on organic soils, recover very slowly, if at all, once altered by artificial flooding or draining.

There are no recognized sections of Wet Meadow. There is one subtype, a Shrub Subtype.

Seepage Meadow

Seepage Meadow probably occurs throughout Minnesota, but is best documented in the St. Croix valley. Skunk cabbage (*Symplocarpus foetidus*) and angelica (*Angelica atropurpurea*) are the dominant plants and are indicative of the community. Graminoid cover is generally low; broad-leaved sedges (*Carex lacustris*, *C. stricta*, *C. stipata*, and *C. comosa*) are the most common graminoid species. Northern marsh fern (*Thelypteris palustris*) and jewel-weed (*Impatiens capensis*) are common cover-forming species. Three rare species--bog bluegrass (*Poa paludigena*), water-pennywort (*Hydrocotyle americana*), and false mermaid (*Floerkea proserpinacoides*)--appear to be endemic to Seepage Meadow communities or to small inclusions of Seepage Meadow in swamp forests.

Seepage Meadows develop around spring heads and in broader areas of groundwater discharge, most commonly in deep glacial meltwater-cut river valleys, at the bases of slopes separating stream terraces. The upwelling groundwater is cold and flows year-round. Peat is present in some seepage areas, sometimes in layers greater than one meter thick. Other seepage areas have little organic material, with the groundwater welling up through carbonate encrusted gravel.

There are no recognized subtypes or sections of Seepage Meadow. Most occurrences of Seepage Meadow are small and are classified as inclusions within seepage subtypes of Tamarack Swamp or Hardwood Swamp communities.

PRIMARY COMMUNITY

Primary Communities comprise all habitats where persistent vegetation is sparse or absent. The forces responsible for the absence of vegetation on a site include wind erosion, wave action, flooding, mass action, and nutrient-poor soils or substrates. These forces may act singly or they may interact. In this classification sites, such as old fields and mine spoils, where the forces preventing the development of vegetation are neither natural nor recurrent, are not considered natural primary communities.

There are seven recognized Primary Community types:

a. community on bedrock, not restricted to shorelines..... **b.**

b. vertical or nearly vertical rock wall, >3m tall ..... **c.**

c. rock face moist with water from condensation or seepage; >30% cover of mosses or foliose lichens ..... ***Moist Cliff***

c. rock face dry, water mostly from precipitation; <30% cover of mosses or foliose lichens ..... ***Dry Cliff***

b. level to steeply inclined area of rock, <3m tall if vertical or nearly nearly vertical ..... **d.**

d. rock consolidated ..... ***Rock Outcrop***

d. rock unconsolidated, colluvium at base of cliff or steep bedrock slope ..... ***Talus Slope***

a. community on rock, sand, or mud along lake and river shorelines ..... **e.**

e. substrate fine textured, composed of allogenic silt and clay mixed with at least some (but often mostly composed of) autogenic sediments, such as gyttja or marl; area normally submerged in spring but exposed by late summer ..... ***Mud Flat***

e. substrate rock or sand, mostly lacking autogenic sediment ..... **f.**

f. shoreline of a river ..... ***River Beach***

f. shoreline of a lake ..... ***Lake Beach***

Moist Cliff

Moist Cliff communities occur on north- to northeast-facing, vertical or nearly vertical exposures of bedrock or unconsolidated material. They also occur on well-shaded overhangs and sometimes on the lower portions of south- to west-facing cliffs, where these are shaded by a forest canopy. Most of the rock surface in the community is kept moist by seepage or condensation. The cool, moist microhabitat in the community supports several rare plant species. Moist Cliff communities often occur upslope from Talus Slope communities and grade into Talus Slope communities.

There are two sections of Moist Cliff, the Southeast Section and the Northeast Section (Fig. 20). These sections occur on different rock types and harbor different plant species. The Southeast Section includes one subtype, the Maderate Subtype.

Most occurrences in the the Southeast Section are on the Paleozoic Plateau of southeastern Minnesota (Fig. 3), with others along the St. Croix Valley in east-central Minnesota. The rock cliffs are formed primarily of limestone or sandstone, and the community usually occurs on these cliffs below forested slopes along major streams and rivers. Characteristic species include bulblet fern (*Cystopteris bulbifera*), fragile fern (*Cystopteris fragilis*), numerous mosses, and mesic forest herbs such as miterwort (*Mitella diphylla*) and wild ginger (*Asarum canadensis*). Moist Cliffs with continuous groundwater seepage over the rock surface often contain additional species such as reniform sullivantia (*Sullivantia renifolia*) and slender cliff-brake (*Crytogramma stelleri*). Two of the rare species present in these southeastern Moist Cliff communities are *Poa wolfii* and shooting star (*Dodecatheon amethystinum*).

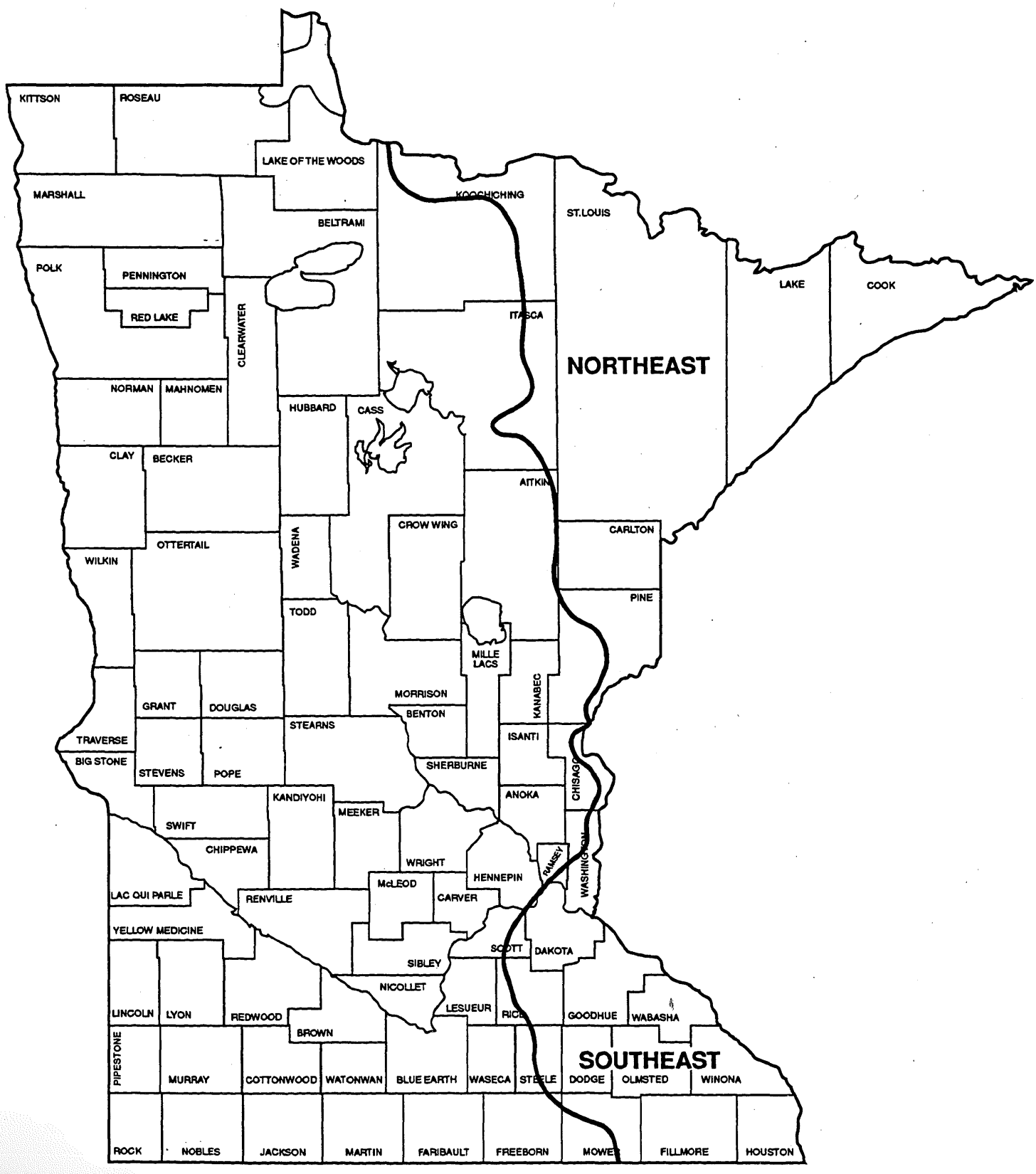
The Maderate Subtype of the Southeast Section of Moist Cliff occurs on rock faces with actively dripping cold water systems that create a cool microhabitat. The Maderate Subtype harbors several rare species of land snails, and two rare but characteristic plant species, Leedy's roseroot (*Sedum integrifolium* var. *leedyi*) and whitlow-grass (*Draba arabisans*). The Maderate subtype is often associated with the Algific Subtype of Talus Slope.

The Northeast Section occurs only in the conifer-hardwood forest zone in extreme northeastern Minnesota, at the bases of shady north-facing diabase cliffs along Lake Superior and the border lakes. The neutral and mildly basic bedrock and constant moisture provide habitat for numerous rare plants, many of which are calcicoles. Characteristic species of the Northeast Section include weak Arctic sedge (*Carex supina*), nodding saxifrage (*Saxifraga cernua*), *Poa scopulorum*, locoweed (*Oxytropis viscida*), whitlow-grass (*Draba arabisans*), and Cathcart's woodsia (*Woodsia oregana* var. *cathcartiana*).

Dry Cliff

Dry cliff communities occur on vertical or nearly vertical, south- to west-facing exposures of bedrock or unconsolidated material. In contrast to Moist Cliffs, Dry Cliffs receive moisture mainly from precipitation. Dry Cliff communities are often present just upslope from

Figure 20. The Southeast and Northeast Sections of Moist and Dry Cliff.



Talus Slope communities, with which they intergrade. There are two recognized sections of Dry Cliff, the Northeast Section and the Southeast Section (Fig. 20). These sections occur on different types of rock and contain different plant species.

Dry Cliff communities in the Southeast Section occur on exposed south- to southwest-facing limestone and sandstone cliffs and ledges, primarily on the Paleozoic Plateau (Fig. 3). The substrate is nutrient poor and sparsely vegetated, but supports a distinctive flora, including the ferns smooth cliff-brake (*Pellaea glabella*), purple cliff-brake (*Pellaea atropurpurea*), and *Woodsia* spp.

In the Northeast Section, the community is present only on dry cliff tops and at the bases of dry, south-facing diabase cliffs. Both arctic-alpine disjunct plant species (e.g., large-leaved sandwort (*Arenaria macrophylla*) and Norwegian draba (*Draba norvegica*)) and temperate plant species occur in the Northeast Section.

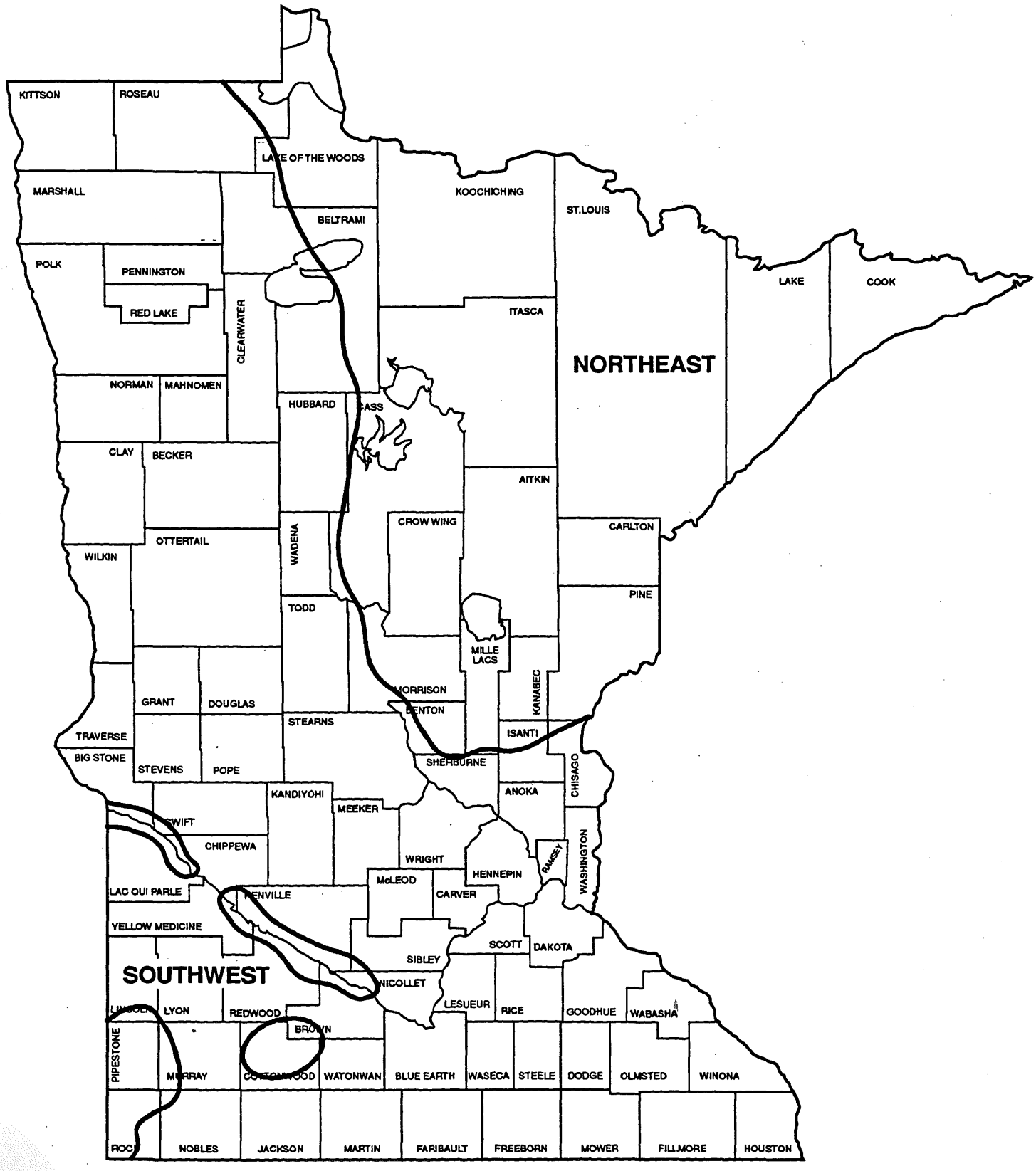
Rock Outcrop

Rock Outcrop communities occur on relatively level or rounded areas of exposed bedrock primarily in northeastern Minnnesota, in the Minnesota River Valley, and in extreme southwestern Minnesota. Rock Outcrop communities typically are sparsely vegetated and have little soil development, with the chemical composition of the bedrock strongly influencing the species composition of the vegetation. The species that persist in the community must survive extreme drought and great fluctations in the temperature of the ground surface. There are two recognized sections of Rock Outcrop, the Southwest Section and the Northeast Section (Fig. 21).

In the Southwest Section, the major occurrences of the community are on rugged bedrock knobs between New Ulm and Ortonville in the Minnesota River Valley, and on local bedrock outcrops in Cottonwood, Pipestone, and Rock counties. The bedrock outcrops in the Minnesota River Valley are composed primarily of granite and gneiss. Most of the plant species present on these outcrops grow in shallow dry soil that collects in small depressions on sloping rock faces. These patches characteristically contain species common to the Great Plains, including brittle opuntia (*Opuntia fragilis*), plains prickly pear (O. macrorhiza), ball cactus (*Coryphantha vivipara*), and wild parsley (*Lomatium orientale*), as well as other species such as rock spikemoss (*Selaginella rupestris*), fameflower (*Talinum parviflorum*), rusty woodsia (*Woodsia ilvensis*), and many spring and early summer blooming annuals.

The rock outcrops in the Minnesota River Valley also usually have two other distinctly vegetated microhabitats: small depressions that collect and hold water and have moist soils for several weeks following rain, and small rock pools (up to one meter or more deep) that contain standing water throughout the growing season. The species present in the moist depressions include Virginia forget-me-not (*Myosotis verna*), Carolina foxtail (*Alopecurus carolinianus*), and mouse-tail (*Myosurus minimus*). The deeper pools contain aquatic plant species, such as water-hyssop (*Bacopa rotundifolia*) and mudwort (*Limosella aquatica*).

Figure 21. The Southwest and Northeast Sections of Rock Outcrop.



The rock outcrops in Cottonwood, Pipestone, and Rock counties differ from those in the Minnesota River Valley in that they occur on outcrops of Sioux quartzite rather than granite or gneiss. However these rock outcrops generally have microhabitats similar to those on the bedrock knobs in the Minnesota River Valley and support many of the same species mentioned above for the Minnesota Valley outcrops.

Rock Outcrop communities in the Northeast Section occur primarily within the conifer-hardwood forest zone, especially on the Canadian Shield (Fig. 7), on granite (and other rock) outcrops on ridgetops, benches, and upper slopes. Occurrences in the Northeast Section are usually a mosaic of exposed rock with patches of low vegetation dominated by fruticose lichens and mosses. Shrubs, many of which have bird-dispersed fruits, frequently grow where thin soils have accumulated in rock crevices. Juneberry species, pin cherries, and bush honeysuckle are common shrubs in the community. The herb flora is depauperate; the most characteristic species are pale corydalis (*Corydalis sempervirens*), bristly sarsaparilla (*Aralia hispidus*), and three-leaved cinquefoil (*Potentilla tridentata*).

Fire appears to be important in maintaining Rock Outcrop communities. In the Northeast Section, in the absence of fire Rock Outcrops are invaded by trees from surrounding forests, especially jack pines and red oaks. In the Southwest Section occurrences of the community in the Minnesota River Valley and along the St. Croix River have also been invaded by trees and shrubs. One of the most significant invading species is eastern red cedar. According to public land survey records and written accounts from early European travelers to the region, red cedars were largely absent from areas of bedrock outcrop in the Minnesota River Valley, and although present on bedrock exposures along the St. Croix Valley, occurred only in areas protected from fire, such as cliffs and steep rocky bluffs. With the onset of extensive settlement and fire suppression, red cedars have spread into many of the outcrop areas, where they displaces the herbs, lichens, and mosses that characterize Rock Outcrop communities.

The Rock Outcrop community type does not generally include natural communities present on the numerous steep cliffs and bedrock bluffs along the St. Croix and Mississippi river valleys in east-central and southeastern Minnesota. These natural community occurrences are classified either as Bedrock Bluff Prairies or as cliff communities, depending on the composition and structure of the vegetation comprising them.

Talus Slope

Talus Slope communities occur in northeastern and southeastern Minnesota in the deciduous forest-woodland and conifer-hardwood forest zones (Fig. 1). They are accumulations of coarse rock and soil at the bases of cliffs and steep slopes. They range in habitat type from shady and moist to exposed and dry. There is one subtype, the Algific Subtype.

The Algific Subtype occurs only on the Paleozoic Plateau in southeastern Minnesota (Fig. 3), at the bases of steep, north-facing dolomite talus slopes. Continuous cold air drainage from fissures and ice caves in the talus creates a cool, moist microclimate in which summer

temperatures rarely excede 16°C. These talus slopes may be small (one square meter), or narrow linear complexes up to 1.5 km long. Disjunct populations of several northern species are present in Algific Talus Slope communities, including miterwort (*Mitella nuda*), Canada mayflower (*Maianthemum canadense*), bunchberry (*Cornus canadensis*), smaller enchanter's nightshade (*Circaea alpina*), tall lungwort (*Mertensia paniculata*), moschatel (*Adoxa moschatellina*), alder-leaved buckthorn, balsam fir, and American yew. The rare boreal disjunct golden saxifrage (*Chrysosplenium iowense*), and several snail species occur in Minnesota only in this community. The more stable upper talus slopes are forested, usually containing northern species such as balsam fir, American yew, and yellow birch. Algific talus slopes are often associated with Moist Cliff (Southeastern Section) Maderate Subtype.

Mud Flat

Mud Flats are communities of shallow basins that flood in the spring and draw down later in the season, exposing wet sediments on which plants subsequently grow. Planktonic, benthic, and macrophyte aquatic communities are present on these sites during flood stages, producing organic detritus and precipitating inorganic salts.

The composition and structure of the vascular vegetation is influenced by the flooding regime and the composition of the sediment. In general, the vegetation is composed of terrestrial forms of aquatic plants and seedlings originating from seeds dormant in the sediment or dispersed from other communities. Most of the vegetation, especially by late summer, is composed of seedlings; species of *Cyperus*, *Scirpus*, *Juncus*, and *Polygonum* present in the seed bank often form luxuriant stands by late summer or autumn. Floating-leaved aquatic species, such as *Nuphar* spp. and *Nymphaea* spp. are common, usually present as rosettes of leaves sprouting from massive rhizomes on the mud surface. Other rooted macrophytes, such as *Potamogeton* spp., *Heteranthera* spp., and water smartweed (*Polygonum amphibium*), are common as well, and quite different in appearance in comparison with their more typical submerged forms.

There is one recognized subtype of Mud Flat, a Saline Subtype. It has several plant species tolerant of high concentrations of dissolved salts. Red glasswort (*Salicornia rubra*), Nuttall's alkali grass (*Puccinellia nuttalliana*), and *Scirpus paludosis* are particularly characteristic. The Saline Subtype occurs only in extreme western Minnesota. Other subtypes (for example, a Calcareous Subtype) and sections of Mud Flat may be recognized eventually following further data collection and analysis.

River Beach

River Beach is a sparsely vegetated community occurring on sand, gravel, cobble, boulder, or bedrock substrates along river shorelines throughout Minnesota. The vegetation of River Beaches is zonal, usually with a distinct upper beach zone and one to several lower beach zones. This zonation is caused by periodic differences in erosion and by differences in exposure

during the growing season as river levels drop. The upper beach zone is often severely eroded by currents, wave action, and ice flows during the spring high-water period. Consequently, perennial species cover is sparse in the upper zone, consisting only of a few species tolerant of inundation and physical fragmentation. Annual species, however, are common in the upper beach zone. The lower beach zones are exposed later in the growing season and contain vegetation consisting of the terrestrial forms of perennial aquatic species and other species--especially annuals--that can survive long periods of inundation.

There are no recognized sections of River Beach, but additional floristic work on river beach communities may reveal considerable floristic difference in beaches in different regions of the state. There are three subtypes of River Beach, the Sand, Gravel-Cobble, and Bedrock subtypes.

Lake Beach

Lake Beach is a sparsely vegetated community occurring on sand, gravel, cobble, boulder, or bedrock substrates along lake shorelines throughout Minnesota. The vegetation of Lake Beach communities is zonal, with a distinct upper beach zone always present and one or more lower beach zones sometimes present. The upper beach zone lies just above the "normal" water level, where the erosive power of wave action and "ice-push" prevent the formation of a stable plant community. The lower beach zone or zones lie below the normal water level. These lower zones are exposed during seasonal periods of low water. They are also exposed during less regular long-term declines in the water level. Lake Beach adjoins a wide variety of terrestrial vegetation types and often grades into Lake Bed or Emergent Marsh communities.

There are two recognized sections of Lake Beach, the Lake Superior Section and the Inland Section.

The Lake Superior Section occurs along the shoreline of Lake Superior. It varies in composition and structure according to substrate. There are three recognized subtypes, the Sand Subtype, the Gravel-Cobble Subtype, and the Bedrock Subtype.

The Sand Subtype occurs only along the northeast side of Minnesota Point in Lake Superior and only about 3 km of the community remains undeveloped. Beach grass (*Ammophila breviligulata*), beach pea (*Lathyrus japonicus*), coast jointweed (*Polygonella articulata*), bug-seed (*Corispermum hyssopifolium*), and false heather (*Hudsonia tomentosa*) are characteristic species of the upper beach zone.

The Gravel-Cobble Subtype is present along the north shore of Lake Superior on wave-washed gravel and cobble beaches and is sparsely vegetated because of disturbance, especially from storm waves. Beach pea (*Lathyrus japonicus*) is a characteristic plant species of the Gravel-Cobble Subtype.

The Bedrock Subtype also occurs along the north shore of Lake Superior, on bare rocks

of the smaller points that extend out into the lake and on wave-swept rocky ledges. The rocks, usually calcic slates and diabase, tend to be cold and wet and provide habitat for a unique assemblage of plants including rare, disjunct arctic-alpine species, such as common butterwort (*Pinguicula vulgaris*) and *Tofieldia vulgaris*. Characteristic species of the subtype include Mistassini primrose (*Primula mistassinica*), Hudson Bay eyebright (*Euphrasia hudsoniana*), northern selaginella (*Selaginella selaginoides*), hair grass (*Deschampsia cespitosa*), and harebell (*Campanula rotundifolia*). Rock crevices are sometimes colonized by mosses and shrubs (especially shrubby cinquefoil, ninebark, and bog laurel).

The Inland Section of Lake Beach occurs on lakes throughout Minnesota. It contains four subtypes, the Sand, Gravel-Cobble, Bedrock, and Mud subtypes.

The Sand Subtype is common along the shores of lakes on sandy outwash plains. It is uncommon on other landforms. The upper beach zone of this subtype has perennial graminoids tolerant of inundation and erosion, and annual species. The lower beach zone has many submergent and floating-leaved aquatic species tolerant of stranding.

There is little information available on the Gravel-Cobble Subtype, but it probably occurs principally along the shores of lakes on the Canadian Shield in northeastern Minnesota and along some of the larger lakes in central and northern Minnesota.

The Bedrock Subtype is present only along shorelines of lakes on the Canadian Shield in northeastern Minnesota. Little information is available on this subtype. There is also little information available on the Mud Subtype.

AQUATIC RIVER COMMUNITY

Aquatic River Communities are present in rivers and streams throughout Minnesota. They have less than 30% cover by persistent vegetation and sparse to continuous cover by nonpersistent vegetation. The vegetation fluctuates greatly in percent cover and species composition because of the erosion and deposition of sediment caused by changes in water levels and currents.

There is on recognized Aquatic River Community type:

a. characterized by few persistent emergent plants, cover mostly submergent and rooted floating-leaved aquatics (Appendix 5) ..... ***River Bed***

AQUATIC LAKE COMMUNITY

Aquatic Lake Communities are present in lakes throughout Minnesota. They have less than 30% cover by persistent vegetation and sparse to continuous cover by nonpersistent vegetation.

There is one recognized Aquatic Lake Community type:

a. characterized by few persistent emergent plants, cover mostly submergent and rooted floating-leaved aquatics (Appendix 5) ..... ***Lake Bed***

Glossary

Aeolian landform -- a landform composed of fine sand or silt deposited by wind (e.g., dune).

Alluvial landform - a landform composed of sorted material (generally sand or gravel) deposited by running water or wave action (e.g., beach ridge, river terrace, fan, outwash plain).

Associates - plant species that tend to co-occur. The probability of finding two associated species growing together is greater than by chance.

Boreal hardwood - a broad-leaved deciduous tree with physiological adaptations enabling survival in regions (especially the boreal forest region of North America) where the temperature may fall below -41°C (e.g., quaking aspen and paper birch).

Brush - a generic term for a moderately dense layer of low shrubs, tall shrubs, and tree saplings, usually used in reference to woodland or brush prairies. In general, brush is composed of woody vegetation less than 3 meters tall, but sometimes up to 5 meters tall.

Canopy - generally the tallest layer of plants in a community. Canopy plants receive direct sunlight and occur in patches of individuals with approximately equal heights.

Colluvium - a deposit of rock and soil at the base of a cliff or steep slope, formed by gravitational action.

Community - an assemblage, that tends to recur over space and time, of plants and animals that interact with each other and their abiotic habitats. Communities are classified and described by considering vegetation, topography, hydrology, landforms, substrates, soils, and disturbance regimes (such as fires, wind storms, flood cycles, and infestation by insects and microorganisms). See also **Natural community**.

Conifer (tree) - a needle-leaved tree with cones (i.e., a gymnosperm).

Cover - the proportion of the ground covered by projecting the plant canopy vertically downward onto the ground. (This would be the proportion of the ground surface shaded by plants if the sun were directly overhead.)

Crested bog - a bog composed of a peat ridge (and its flanks) raised above the local water table because of the accumulation of sphagnum mosses. Crested bogs are generally forested by black spruce and are components of the large peatland complexes in northern Minnesota.

Domed bog - a bog composed of a relatively circular mound of peat raised above the local water table because of the accumulation of sphagnum mosses. Domed bogs are generally forested by black spruce. They are often parts of the large peatland complexes in northern Minnesota but also occur in isolated kettle-holes.

Glossary

Dominant - a plant species that shapes the character of a community by virtue of its great size, dense shade, allelochemic properties, or effects on soils. Dominant species generally influence the presence, growth, and distribution of other plant species in the community.

Emergent - a plant capable of surviving indefinitely with its root system and lower stem submerged and its aerial shoots above water (e.g., cattails).

Floodplain (active) - a flat terrace along a stream or river, created by erosion and deposition of sediment during flood cycles. Signs of active flooding include debris caught in trees growing on the floodplain or ice scars at the bases of the trees.

Gleyed soil - a poorly drained soil with gray coloring or mottling caused by the reduction of iron and other elements that occurs under poor drainage conditions.

Graminoid - a plant with linear "grass-like" leaves that typically branch vertically from the stem. Graminoids are members of the Gramineae, Cyperaceae, Juncaceae, Iridaceae, Typhaceae, Sparginiaceae, and other families.

Groundlayer - a vegetation layer, less than 1 meter tall, of grasses, herbs, and half-shrubs. (The groundlayer does not include tree seedlings or true shrubs).

Heliophilous - sun-loving

Herbaceous - a plant without a persistent above-ground woody stem.

Hydric soil - a soil wet long enough to be periodically anaerobic.

Hydrophyte - a plant able to grow in water or on wet soils that are periodically saturated and deficient in oxygen.

Mature tree - a tree greater than 5 meters tall.

Mesic habitat - a habitat with average soil moisture, where soil moisture is not limiting to plant growth during the growing season, and soils are not saturated except following rain or spring snowmelt.

Mesic hardwood - a broad-leaved deciduous tree generally not capable of growing in the boreal region of North America. Mesic hardwoods have physiological adaptations that protect them from freezing temperatures above, but not below, -41°C (e.g., maples, ashes, elms).

Mineral soil - a soil composed mostly of inorganic matter, including clay, silt, sand, and gravel. Mineral soils usually have less than 20% organic matter but may have organic surface layers up

to 30cm thick.

Minerotrophic - a wetland receiving nutrients from groundwater as well as from rainwater, or a wetland with peat and surface water nutrient content considerably higher than that of rainwater.

Modal - a species of a community that has its highest frequency of occurrence in that community.

Mollic epipedon - a soft, dark, prairie-soil surface horizon, rich in nutrients (>50% base saturation), high in organic matter, with a C:N ratio of less than 17:1 (uncultivated), and less than 250 mg/l P_2O_5 soluble in citric acid.

Mostly - more than half. Generally used in describing the cover of a dominant plant in a community.

Mottled soil - a soil with spots or blotches of a color different from the base color of the soil. Mottling results from cycles of anaerobic and aerobic conditions caused by cycles of soil saturation and drying.

Native - a species that existed in Minnesota prior to European settlement.

Natural community - an assemblage, that tends to recur over space and time, of native plants and animals that interact with each other and their abiotic habitats in ways little modified by humans or non-native species. Natural communities are classified and described by considering vegetation, successional status, topography, hydrology, landforms, substrates, soils, and natural disturbance regimes (such as wild fires, wind storms, normal flood cycles, and normal infestation by native insects and microorganisms).

Oligotrophic - a minerotrophic wetland poor in nutrients.

Ombrotrophic - a wetland receiving nutrients solely form rainwater, or a wetland with peat and surface water nutrient content not exceeding that of rainwater. Ombrotrophic conditions develop in areas where the center of a bog is higher than its margins and is cut off from groundwater flow. Ombrotrophic bogs have low pH (usually less than 4).

Ovoid island - a streamlined, oval-shaped peatland landform supporting bog vegetation. Ovoid islands are believed to be remnants of crested or domed bogs. Their characteristic shapes presumably are caused by the flow of mineral-rich water (water tracks) around their margins.

Patterned peatland - a large peatland composed of mosaics of interrelated landforms (crested and domed bogs, water tracks, ovoid islands, teardrop islands, lawns).

Glossary

Peat soil - unconsolidated soil consisting largely of undecomposed (fibric peat), slightly decomposed (hemic peat), or mostly decomposed (sapric peat or muck) organic matter accumulated under conditions of excessive moisture.

Persistent vegetation - emergent hydrophytes with stems that normally remain standing until the beginning of the following growing season (e.g., cattails and bulrushes).

Physiognomy - the gross external appearance or structure of vegetation. Used loosely, physiognomy also refers to biomass structure (i.e., the spacing, height, and life-form groups of plants in a community).

Short-shrub layer - a vegetation layer of shrubs and tree seedlings and saplings between 0 and 2 meters tall.

Subcanopy - a vegetation layer, composed of patches of individuals of approximately equal height, that is lower than the canopy layer. Subcanopy often refers to a layer of smaller trees under a tree canopy.

Submergent vegetation - plants growing mostly under water.

Tall-shrub layer - a vegetation layer composed of obligate shrub species and tree saplings between 2 and 5 meters tall.

Terrestrial plant - terrestrial plants include all species adapted for growth on somewhat poorly drained to excessively drained mineral soils (i.e., mineral soils that are not hydric) . Such soils lack hydric characteristics such as accumulated peat or gleyed or mottled horizons. Some plants are physiologically adapted to both terrestrial and wetland conditions, and are considered terrestrial plants when growing under terrestrial conditions and wetland plants when growing under wetland conditions.

Tree cover - the proportion of the ground covered by the vertical projection downward of the mature tree canopy.

Understory - the vegetation occurring below the canopy in a plant community.

Appendix 1. Natural community types, sections, and subtypes

(* = together, the subtypes listed for this community type or section are exhaustive; the category (i.e. community type or section) without a subtype is maintained to provide a place in the Heritage Database for occurrences that have not been identified to subtype)

The state ranks

The numerical ranks assigned to natural community types and subtypes in this appendix are intended to reflect the extent and condition of the natural communities in Minnesota. Communities are ranked on a scale from 1 to 5; those ranked "1" are considered critically endangered in Minnesota, while communities ranked "5" are considered secure under present conditions.

The community ranks were determined by Natural Heritage Program and Minnesota County Biological Survey ecologists using current information from the Natural Heritage Information System, field observations, and other sources. The ranks are based **principally** on the abundance of high-quality examples of each community. For example, the rank for northern hardwood forest was determined mainly by considering the abundance of northern hardwood forests that have mature trees and a diverse groundlayer composed of native plants, and that have had little if any logging in the past.

Ranks for some of the communities may be revised as the Minnesota County Biological Survey progresses and more information is obtained on natural communities statewide. A question mark following a rank is used in cases where only limited information is available on the community. Communities for which infomation is especially scarce are given a "U", for rank undetermined.

The community ranks assigned here are used by the Minnesota Natural Heritage Program to set priorities for research and for conservation planning. These ranks do not imply any statutory or regulatory protection for natural communities as such; there is no "Endangered Natural Community Act." However, several of the natural communities in this list are afforded some protection incidentally under various State and Federal wetland laws or regulations. Occurrences of one natural community, ***Calcareous Seepage Fen Prairie Subtype***, are explicitly protected, as "calcareous fens," under the Wetland Conservation Act (Minn. Stat. § 103G.223, Minn. Rules ch. 8420.1010-1060), and the Water Pollution Control Act (Minn. Stat. §§ 115.03, 115.44, Minn. Rules ch. 7050.0180).

	State Rank
DECIDUOUS FOREST	
Aspen Forest	5
Aspen - Birch Forest	4?
*Aspen - Birch Forest Spruce-Fir Subtype**	4?
*Aspen - Birch Forest Northern Hardwoods Subtype**	4?
Paper Birch Forest	4?
*Paper Birch Forest Spruce-Fir Subtype**	4?
*Paper Birch Forest Northern Hardwoods Subtype**	4?

Oak Forest *(Southeast Section)*	2
Oak Forest *(Southeast Section) Dry Subtype**	2
Oak Forest *(Southeast Section) Mesic Subtype**	2
Oak Forest *(Big Woods Section)*	3
Oak Forest *(Big Woods Section) Dry Subtype**	3
Oak Forest *(Big Woods Section) Mesic Subtype**	2
Oak Forest *(Central Section)*	3
Oak Forest *(Central Section) Dry Subtype**	3
Oak Forest *(Central Section) Mesic Subtype**	2
Oak Forest *(Northwest Section)*	U
Oak Forest *(Northwest Section) Dry Subtype**	U
Oak Forest *(Northwest Section) Mesic Subtype**	U
Oak Forest *(Northeast Section)*	3
Oak Forest *(Northeast Section) Red Maple Subtype*	4
Northern Hardwood Forest *(Southeast Section)*	2
Northern Hardwood Forest *(Northern Section)*	2
Maple - Basswood Forest *(Southeast Section)*	2
Maple - Basswood Forest *(Big Woods Section)*	2
Maple - Basswood Forest *(East Central Section)*	3
Maple - Basswood Forest *(West Central Section)*	3
Maple - Basswood Forest *(Northern Section)*	3
Lowland Hardwood Forest	4

CONIFEROUS FOREST

White Pine Forest *(Southeast Section)*	2
White Pine Forest *(Central Section)*	2
White Pine Forest *(Northeast Section)*	3

Red Pine Forest	3
Jack Pine Forest (Central Outwash Plain Section)	4
*Jack Pine Forest (Central Outwash Plain Section) Hazel Subtype**	4
*Jack Pine Forest (Central Outwash Plain Section) Blueberry Subtype**	3
Jack Pine Forest (Northeast Section)	4
Jack Pine Forest (Northeast Section) Jack Pine - Oak Subtype	4?
Jack Pine Forest (Northeast Section) Jack Pine - Fir Subtype	4
Jack Pine Forest (Northeast Section) Jack Pine - Black Spruce Subtype	4
Jack Pine Forest (Northwest Section)	3
Black Spruce - Feathermoss Forest	4
Spruce - Fir Forest	4
Spruce - Fir Forest Fir - Birch Subtype	4
Spruce - Fir Forest White Spruce - Balsam Fir Subtype	3
Upland White Cedar Forest	3
Upland White Cedar Forest (Northern Section)	3
Upland White Cedar Forest (Northern Section) Mesic Subtype	3
Upland White Cedar Forest (Northern Section) Wet - Mesic subtype	2?
Upland White Cedar Forest (Lake Superior Section)	3
Upland White Cedar Forest (Lake Superior Section) Mesic Subtype	3
Upland White Cedar Forest (Lake Superior Section) Wet - Mesic Subtype	3
Upland White Cedar Forest (Southeast Section)	2

MIXED CONIFEROUS-DECIDUOUS FOREST

Mixed Pine - Hardwood Forest	4
White Pine - Hardwood Forest (Southeast Section)	
*White Pine - Hardwood Forest (Southeast Section) Dry Subtype**	2
*White Pine - Hardwood Forest (Southeast Section) Mesic Subtype**	2

White Pine - Hardwood Forest (North-Central Section)	3
Boreal Hardwood - Conifer Forest	3?
Northern Hardwood - Conifer Forest (Southeast Section)	2
Northern Hardwood - Conifer Forest (Northern Section)	3
Northern Hardwood - Conifer Forest (Northern Section) Yellow Birch - White Cedar Subtype	2

DECIDUOUS WOODLAND

Aspen Woodland	5
Oak Woodland - Brushland (Southeast Section)	4
Oak Woodland - Brushland (Big Woods Section)	4
Oak Woodland - Brushland (Central Section)	4
Oak Woodland - Brushland (Northwest Section)	4

DECIDUOUS SAVANNA

Mesic Oak Savanna (Southeast Section)	1
Mesic Oak Savanna (Southwest Section)	1
Mesic Oak Savanna (Central Section)	1
Mesic Oak Savanna (Northwest Section)	1
Dry Oak Savanna (Southeast Section)	U
*Dry Oak Savanna (Southeast Section) Barrens Subtype**	1
*Dry Oak Savanna (Southeast Section) Hill Subtype**	1?
*Dry Oak Savanna (Southeast Section) Sand - Gravel Subtype**	2
Dry Oak Savanna (Southwest Section)	U
*Dry Oak Savanna (Southwest Section) Hill Subtype**	1

Dry Oak Savanna (Central Section)	U
*Dry Oak Savanna (Central Section) Barrens Subtype**	2
*Dry Oak Savanna (Central Section) Hill Subtype**	1
*Dry Oak Savanna (Central Section) Sand - Gravel Subtype**	2
Dry Oak Savanna (Northwest Section)	U
*Dry Oak Savanna (Northwest Section) Barrens Subtype**	1
*Dry Oak Savanna (Northwest Section) Hill Subtype**	1
*Dry Oak Savanna (Northwest Section) Sand - Gravel Subtype**	1
Aspen Openings	2
Aspen Openings Sand - Gravel Subtype	1

CONIFEROUS WOODLAND

Jack Pine Woodland	1
Northern Conifer Woodland	4?

CONIFEROUS SAVANNA

Jack Pine Barrens	2
Northern Conifer Scrubland	3?

UPLAND BRUSH-PRAIRIE

Mesic Brush-Prairie	3
Mesic Brush-Prairie Sand - Gravel Subtype	2

UPLAND PRAIRIE

Mesic Prairie (Southeast Section)	1
Mesic Prairie (Southwest Section)	2
Mesic Prairie (Southwest Section) Crystalline Bedrock Subtype	1

Mesic Prairie (Central Section)	2
Mesic Prairie (Central Section) Carbonate Bedrock Subtype	1
Mesic Prairie (Northwest Section)	3
Dry Prairie (Southeast Section)	3
Dry Prairie (Southeast Section) Barrens Subtype	1
Dry Prairie (Southeast Section) Bedrock Bluff Subtype	3
Dry Prairie (Southeast Section) Hill Subtype	2
Dry Prairie (Southeast Section) Sand - Gravel Subtype	2
Dry Prairie (Southwest Section)	3
Dry Prairie (Southwest Section) Hill Subtype	3
Dry Prairie (Southwest Section) Sand - Gravel Subtype	2
Dry Prairie (Central Section)	2
Dry Prairie (Central Section) Barrens Subtype	2
Dry Prairie (Central Section) Hill Subtype	2
Dry Prairie (Central Section) Sand - Gravel Subtype	2
Dry Prairie (Northwest Section)	3
Dry Prairie (Northwest Section) Barrens Subtype	1
Dry Prairie (Northwest Section) Hill Subtype	3
Dry Prairie (Northwest Section) Sand - Gravel Subtype	2

BOG

Black Spruce Bog	4
*Black Spruce Bog Raised Subtype**	3
*Black Spruce Bog Intermediate Subtype**	4
Open Sphagnum Bog	4
*Open Sphagnum Bog Raised Subtype**	3
*Open Sphagnum Bog Intermediate Subtype**	4
*Open Sphagnum Bog Schlenke Subtype**	2

FLOODPLAIN FOREST

Floodplain Forest	2
Floodplain Forest Silver Maple Subtype	3
Floodplain Forest Swamp White Oak Subtype	2?

HARDWOOD SWAMP FOREST

Black Ash Swamp	4
Black Ash Swamp Seepage Subtype	3
Mixed Hardwood Swamp	4
Mixed Hardwood Swamp Seepage Subtype	3

CONIFER SWAMP FOREST

White Cedar Swamp	4
White Cedar Swamp Seepage Subtype	2?
Tamarack Swamp	4
*Tamarack Swamp Sphagnum Subtype**	4
*Tamarack Swamp Minerotrophic Subtype**	4
*Tamarack Swamp Seepage Subtype**	2
Black Spruce Swamp	4

SHRUB SWAMP

Alder Swamp	5
Willow Swamp	4

EMERGENT MARSH

Cattail Marsh	5
Mixed Emergent Marsh (Forest Section)	4
Mixed Emergent Marsh (Prairie Section)	2

WET MEADOW/FEN

Wet Brush-Prairie	3
Wet Brush-Prairie Seepage Subtype	2

Wet Prairie (Southeast Section)	1
Wet Prairie (Southwest Section)	2
Wet Prairie (Southwest Section) Saline Subtype	1
Wet Prairie (Central Section)	2
Wet Prairie (Central Section) Seepage Subtype	1?
Wet Prairie (Northwest Section)	3
Wet Prairie (Northwest Section) Saline Subtype	2
Wet Prairie (Northwest Section) Seepage Subtype	2
Poor Fen	4
*Poor Fen Sedge Subtype**	3
*Poor Fen Shrub Subtype**	4
*Poor Fen Scrub Tamarack Subtype**	4
*Calcareous Seepage Fen (Southeast Section) Prairie Subtype**	1
*Calcareous Seepage Fen (Southwest Section) Prairie Subtype**	1
*Calcareous Seepage Fen (Northwest Section) Prairie Subtype**	1
*Calcareous Seepage Fen Boreal Subtype**	2
Rich Fen (Boreal Section)	4
*Rich Fen (Boreal Section) Sedge Subtype**	4
*Rich Fen (Boreal Section) Floating-Mat Subtype**	U
*Rich Fen (Boreal Section) Shrub Subtype**	4
Rich Fen (Transition Section)	3
*Rich Fen (Transition Section) Sedge Subtype**	3
*Rich Fen (Transition Section) Floating-Mat Subtype**	3?
*Rich Fen (Transition Section) Shrub Subtype**	3
Wet Meadow	3
Wet Meadow Shrub Subtype	3
Seepage Meadow	3

PRIMARY COMMUNITY _____

Moist Cliff (Southeast Section)	3
Moist Cliff (Southeast Section) Maderate Subtype	3
Moist Cliff (Northeast Section)	4
Dry Cliff (Southeast Section)	3
Dry Cliff (Northeast Section)	4
Rock Outcrop (Southwest Section)	3
Rock Outcrop (Northeast Section)	4
Talus Slope	U
Talus Slope Algific Subtype	2
Mud flat	U
Mud flat Saline Subtype	1
River Beach	U
River Beach Sand Subtype	U
River Beach Gravel - Cobble Subtype	U
River Beach Bedrock Subtype	U
Lake Beach (Lake Superior Section)	4
*Lake Beach (Lake Superior Section) Sand Subtype**	1
*Lake Beach (Lake Superior Section) Gravel - Cobble Subtype**	4
*Lake Beach (Lake Superior Section) Bedrock Subtype**	4
Lake Beach (Inland Section)	4
*Lake Beach (Inland Section) Mud Subtype**	4
*Lake Beach (Inland Section) Sand Subtype**	3
*Lake Beach (Inland Section) Gravel - Cobble Subtype**	4
*Lake Beach (Inland Section) Bedrock Subtype**	4

AQUATIC RIVER COMMUNITY _____

River Bed	U

AQUATIC LAKE COMMUNITY _____

Lake Bed	U

Appendix 2. Common names and taxonomic equivalents of tree, shrub, and ericaceous shrub species appearing in *Minnesota's Native Vegetation*. (**b** = boreal hardwood species, **m** = mesic hardwood species)

Common Name	Taxonomic Equivalent
Trees	
American elm (**m**)	*Ulmus americana*
American hornbeam (**m**)	*Carpinus caroliniana*
ash	*Fraxinus* sp.
aspen	*Populus* sp.
balsam fir	*Abies balsamea*
balsam poplar (**b**)	*Populus balsamifera*
basswood (**m**)	*Tilia americana*
big-toothed aspen	*Populus grandidentata*
bitternut hickory (**m**)	*Carya cordiformis*
black ash (**b**)	*Fraxinus nigra*
black cherry	*Prunus serotina*
black oak	*Quercus velutina*
black spruce	*Picea mariana*
black willow	*Salix nigra*
box elder	*Acer negundo*
bur oak	*Quercus macrocarpa*
butternut (**m**)	*Juglans cinerea*
chokecherry (**b**)	*Prunus virginiana*
cottonwood	*Populus deltoides*
eastern red cedar	*Juniperus virginiana*
elm	*Ulmus* sp.
green ash (**m**)	*Fraxinus pennsylvanica*
hackberry (**m**)	*Celtis occidentalis*
ironwood (**m**)	*Ostrya virginiana*
jack pine	*Pinus banksiana*
mountain ash (**b**)	*Sorbus americana*
northern pin oak	*Quercus ellipsoidalis*
northern red oak (**m**)	*Quercus rubra*
oak	*Quercus* sp.
paper birch (**b**)	*Betula papyrifera*
pincherry (**b**)	*Prunus pensylvanica*
pine	*Pinus* sp.
pussy willow (**b**)	*Salix discolor*
quaking aspen (**b**)	*Populus tremuloides*
red maple (**m**)	*Acer rubrum*
red pine	*Pinus resinosa*

river birch	*Betula nigra*
rock elm (**m**)	*Ulmus thomasii*
silver maple	*Acer saccharinum*
slippery elm (**m**)	*Ulmus rubra*
sugar maple (**m**)	*Acer saccharum*
tamarack	*Larix laricina*
white ash (**m**)	*Fraxinus americana*
white cedar	*Thuja occidentalis*
white oak (**m**?)	*Quercus alba*
white pine	*Pinus strobus*
white spruce	*Picea glauca*
willow	*Salix* sp.
yellow birch (**m**)	*Betula alleghaniensis*

Shrubs

alder	*Alnus* sp.
alder buckthorn	*Rhamnus frangula*
alder-leaved buckthorn	*Rhamnus alnifolia*
American hazelnut	*Corylus americana*
American yew	*Taxus canadensis*
balsam willow	*Salix pyrifolia*
beaked hazel	*Corylus cornuta*
Bebb's willow	*Salix bebbiana*
blackberry	*Rubus allegheniensis*
bog birch	*Betula pumila* var. *glandulifera*
bog willow	*Salix pedicellaris*
bush honeysuckle	*Diervilla lonicera*
bush juniper	*Juniperus communis*
common buckthorn	*Rhamnus cathartica*
downy arrowwood	*Viburnum rafinesquianum*
fly honeysuckle	*Lonicera canadensis*
fragrant false indigo	*Amorpha nana*
gooseberry	*Ribes* sp.
gray-bark dogwood	*Cornus foemina* ssp. *racemosa*
hazelnut	*Corylus* sp.
juneberry	*Amelanchier* sp.
leadplant	*Amorpha canescens*
leatherwood	*Dirca palustris*
meadow sweet	*Spiraea alba*
mountain fly-honeysuckle	*Lonicera villosa*
mountain maple	*Acer spicatum*
ninebark	*Physocarpus opulifolius*
pagoda dogwood	*Cornus alternifolia*
poison sumac	*Rhus vernix*

prairie rose	*Rosa arkansana*
prairie willow	*Salix humilis*
prickly ash	*Zanthoxylum americanum*
pussy willow	*Salix discolor*
raspberry	*Rubus strigosus*
red-berried elder	*Sambucus pubens*
red-osier dogwood	*Cornus stolonifera*
round-leaved dogwood	*Cornus rugosa*
sage-leaved willow	*Salix candida*
sand-bar willow	*Salix exigua* (formerly *S. interior*)
sand cherry	*Prunus pumila*
Saskatoon	*Amelanchier alnifolia*
shrubby cinquefoil	*Potentilla fruticosa*
slender willow	*Salix gracilis*
speckled alder	*Alnus incana* ssp. *rugosa*
Tartarian honeysuckle	*Lonicera tatarica*
willow	*Salix* sp.
winterberry	*Ilex verticillata*
wolfberry	*Symphoricarpos occidentalis*

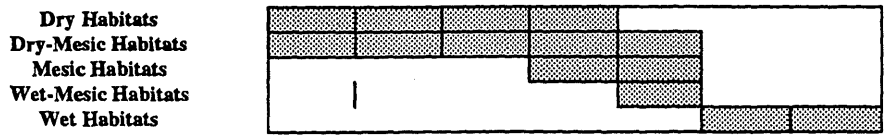
Ericaceous shrubs

blueberry	*Vaccinium angustifolium*
bog rosemary	*Andromeda glaucophylla*
creeping snowberry	*Gaultheria hispidula*
Labrador tea	*Ledum groenlandicum*
leatherleaf	*Chamaedaphne calyculata*
swamp laurel	*Kalmia polifolia*

Appendix 3. Common plants of prairie communities in Minnesota, by community in which they ocur.
(Emphasis is on species that occur throughout the range of the community in Minnesota; exceptions are noted (e.g., -SE = absent from southeastern Minnesota, NW = typical in Northwestern Minnesota). Species that may be common in a prairie community but that are also typical of non-prairie communities (such as Sedge Meadow) are omitted.)

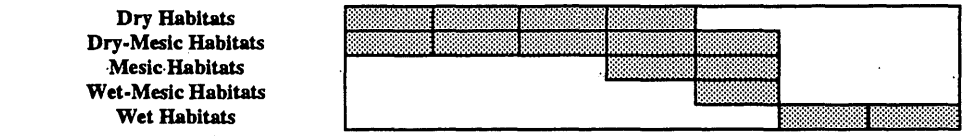
T = typically present
O = occasional but not typical, or typically present only in some subtypes

Barrens = Dry Prairie Barrens Subtype and Dry Oak Savanna Barrens Subtype
Gravel = Dry Prairie Sand-Gravel Subtype
Bluff = Dry Prairie Bedrock Bluff Subtype
Hill = Dry Prairie Hill Subtype and Dry Oak Savanna Hill Subtype
Mesic = Mesic Prairie and Mesic Brush Prairie
Wet = Wet Prairie and Wet Brush Prairie
Saline = Wet Prairie Saline Subtype



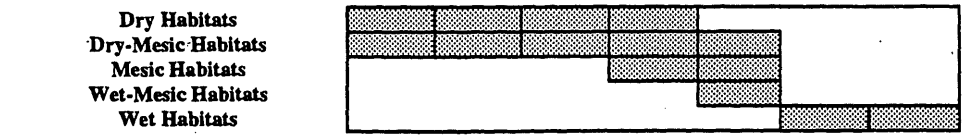
Species	Barrens	Gravel	Bluff	Hill	Mesic	Wet	Saline
Graminoids							
Calamovilfa longifolia	T	O		O			
Bouteloua gracilis	T(NW)	T(NW)		O(NW)			
Bouteloua hirsuta	T	T	T	O			
Muhlenbergia cuspidata		T	T	T			
Carex heliophila	T	T	T	T	T		
Stipa spartea	T	T	T	T	T		
Koeleria macrantha	T	T	T	T	T		O
Bouteloua curtipendula	O	T	T	T	T		
Schizachyrium scoparium	T	T	T	T	T	O	T
Panicum leibergii		O	T	T	T		
Sorghastrum nutans	O	O	T	T	T	O	O
Sporobolus heterolepis		T	T	T	T	O	O
Andropogon gerardii	T	T	T	T	T	T	T
Panicum virgatum				O	T	T	T
Muhlenbergia richardsonis (-SE?)					O	T	T
Spartina pectinata					O	T	T
Hierochloe odorata					O	T	O
Distichlis stricta							T
Muhlenbergia asperifolia							T
Spartina gracilis							T
Puccinellia nuttalliana							O
Broad-leaved Herbs							
Petalostemon villosum	T						
Tradescantia occidentalis	T						
Artemisia frigida	T	T	O	O			
Pulsatilla nuttalliana	T	T	T	T	O		
Castilleja sessiliflora		T	T	O			
Aster oblongifolius		T	T	T	O		
Lithospermum incisum	O	T	T	O			
Liatris cylindracea			T	O(C)			
Liatris punctata	O	T	O	T	O		
Aster sericeus	T	T	T	T	O		
Liatris aspera	T	T	T	T	T		
Heterotheca villosa	T	T		T	O		
Geum triflorum	O	T	T	T	T		
Delphinium virescens	T	T	O	T	T		
Anemone cylindrica	T	T	T	T	T		
Helianthus rigidus	T	T	T	T	T		
Astragalus crassicarpus		T	O	T	T		
Echinacea angustifolia (-E)		T		T	O		
Calylophus serrulatus	O	T	O	T	O		
Psoralea argophylla		O		T	T		

Appendix 3. ((cont.)



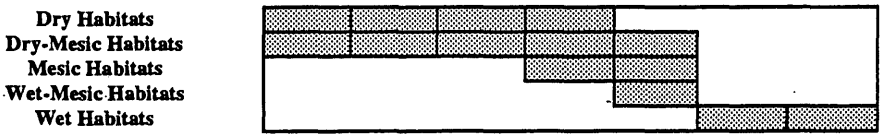
Species	Barrens	Gravel	Bluff	Hill	Mesic	Wet	Saline
Broad-leaved Herbs (cont.)							
Psoralea esculenta		T	O	T	T		
Senecio plattensis		T	O	T	O		
Potentilla arguta	O	T	T	T	T		
Petalostemon candidum	O	O	O	O	T		
Heuchera richardsonii	O	T	O	T	T		
Comandra umbellata	T	T	T	T	T	O	
Solidago rigida	T	T	T	T	T	O	
Solidago nemoralis	T	T	T	T	T	O	O/T
Sisyrinchium campestre	T	T	T	T	O		
Solidago missouriensis	T	T	O	T	T		
Solidago ptarmicoides		T	T	T	T	O	
Allium stellatum		T		T	T	O	O
Lithospermum canescens		T	T	T	T	O	
Artemisia ludoviciana	T	T	O	T	T		
Petalostemon purpureum	O	T	T	T	T	O	O
Phlox pilosa (-NW)	O	O	O	T	T		
Aster laevis		T	O	T	T		
Coreopsis palmata (-NW)	T	T	T	T	T		
Viola pedatifida	T	T	T	T	T	O	
Cirsium flodmanii		T		T	T	O	
Lilium philadelphicum		O	O	T	T	O	
Zizia aptera		O	O	T	T	O	T
Zigadenus elegans		O	O	T	T	O	O
Oxalis violacea		O	O	T	T		
Asclepias speciosa		O			T	O	
Pedicularis canadensis			T	O	T	O	
Thalictrum dasycarpum				T	T	T	
Glycyrrhiza lepidota				O	T	O	
Helianthus maximilianii				O	T	O	O
Prenanthes racemosa				O	T	O	
Heliopsis helianthoides					T	O	
Liatris ligulistylis					T	T	T
Pycnanthemum virginianum					O	T	
Liatris pycnostachya					O	T	O
Aster novae-angliae					O	T	
Hypoxis hirsuta					O	T	
Zizia aurea					O	T	
Gentiana andrewsii					O	T	
Lysimachia quadriflora					O	T	
Solidago riddellii					O	T	
Euthamia graminifolia					O	T	O
Plantago eriopoda							T
Shrubs							
Amorpha canescens	T	T	T	T	T		

Supplement to Appendix 3. Species of more restricted geographic distribution, species not so clearly indicative of prairie vegetation or species whose status is unknown.



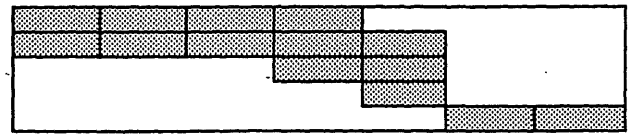
Species	Barrens	Gravel	Bluff	Hill	Mesic	Wet	Saline
Graminoids							
Agropyron trachycaulum var unilat.		O		T	T		
Agropyron trachycaulum var. glauc.					O	T	T
Aristida basiramea (E)	T						
Calamagrostis canadensis						T	
Calamagrostis inexpansa (-SE)					O	T	T
Carex bebbii					O?	T?	
Carex bicknellii	O?			O?	T?	?	
Carex crawei (NW)					O	T	
Carex eleocharis (W)	?	T		O			
Carex filifolia (W)		T		O			
Carex foenea	T	O					
Carex hallii							T
Carex lanuginosa					O	T	
Carex meadii			O	T	T		
Carex muhlenbergii (E)	T	O					
Carex praegracilis (-SE)						O	T
Carex sartwellii						O	
Carex tetanica					O	T	
Cyperus schweinitzii	T						
Elymus canadensis					O?		
Eragrostis spectabilis	O	O?			O?		
Glyceria striata						T	
Helictotrichon hookeri (NW)		T					
Leptoloma cognatum (SE)	T						
Muhlenbergia glomerata						O	
Panicum lanuginosum						T	
Panicum oligosanthes		T	T	O	T		
Panicum perlongum	T	O	T	O			
Panicum wilcoxianum		T		T	O		
Sporobolus asper		O		T?	?	O	T
Sporobolus cryptandrus	T	O					
Stipa comata (W?)	T?	T		O			
Broad-leaved Herbs							
Agalinus aspera		?		T	O?		
Agalinus tenuifolia						O?	
Agoseris glauca (W)		T		T	T	O	
Allium canadense					?	T	
Allium textile (W)		T					
Ambrosia coronopifolia	T	?		?	T		T
Anemone canadensis					O	T	
Antennaria plantaginifolia	T	T	O				
Apocynum sibiricum				O	T	T	
Asclepias incarnata						T	
Asclepias lanuginosa		?		T?			
Asclepias ovalifolia				O	T		
Asclepias tuberosa (SC, SE)	T	O	O	T	T		
Asclepias viridiflora	T	T	O	T			
Aster ericoides		T	T	T	T	O	T
Aster lanceolatus					O	T	O
Aster umbellatus (-SW)						O	
Astragalus adsurgens (W)		T		T			
Astragalus agrestis (W)				O	T	O	
Cacalia tuberosa (SE)					T?	T?	
Cerastium arvense	?	T		O?			
Cicuta maculata					O	T	
Cirsium muticum (-SW)						O	

Supplement to Appendix 3. (cont.)



Species	Barrens	Gravel	Bluff	Hill	Mesic	Wet	Saline
Broad-leaved Herbs (cont.)							
Cypripedium candidum					O	T	
Desmodium canadense					T	T	
Equisetum hymale	T?	?	O	T?			
Equisetum laevigatum		O			T?		
Erysimum inconspicuum		T?		T	O		
Eupatorium maculatum						T	
Euphorbia corollata (-W)	T	T	T	T	O?		
Euthamia gymnospermoides	O	O		T?	T?		
Gaillardia aristata		T		O?			
Galium boreale	O	T	O	T	T	O	
Gaura coccinea (W)		T		T	O		
Gentiana puberulenta		?	?	T	T		
Gentianopsis crinita						O	
Gentianopsis procera (-S)						O	
Helenium autumnale					O	T	
Helianthemum bicknellii (-SW)	T						T
Helianthus giganteus					O	T	
Helianthus grosseserratus					O	T	
Helianthus occidentalis (-W)	T		O	?	T?		
Hudsonia tomentosa	T						
Kuhnia eupatorioides		T	T	T			
Lactuca ludoviciana		?		T	O		
Lactuca pulchella	?	T		T	O		
Lathyrus palustris					O	T	
Lathyrus venosus					T		
Lechea stricta (-W)	T	T	O	?			
Lespedeza capitata	T	O	O		O		
Lilium michiganense (-W)						T	
Linum rigidum (-E?)		T		O			
Linum sulcatum		T	T	T	T		
Lithospermum caroliniense (E)	T	T	O	O?			
Lobelia kalmii (N)						O	
Lobilia siphilitica (-N)						T	
Lobelia spicata			T	O	T	O	
Lomatium orientale (W)		T		O			
Lythrum alatum						T	
Nothocalais cuspidata (-NW)		T		O			
Oenothera nuttallii (NW?)	T	T		?			
Onosmodium molle		O	O	O	T		
Oxytropis lambertii (W)		T		T			
Pedicularis lanceolata						T	
Penstemon albidus (W)		T		O			
Penstemon gracilis	?	T	O	O?	O?		
Physalis heterophylla				O	T		
Physalis virginiana	O	T	T	T	O		
Polygala senega					T	?	
Polygala verticillata		O		T?	O		
Potentilla pensylvanica (-SE)		T		T			
Ranunculus rhomboideus	O	O	O?	T	O		
Ratibida columnifera (W?)		T		T	O		
Ratibida pinnata (S)			T	O	T		
Senecio aureus						T?	
Senecio integerrimus					T?	?	
Senecio pseudaureus						T	
Silphium laciniatum (S)		T?	T	T	O		
Sisyrinchium montanum					T		
Sisyrinchium mUcronatum						T	
Solidago gigantea						T	
Solidago speciosa	T?	O?	O?	O?	T		

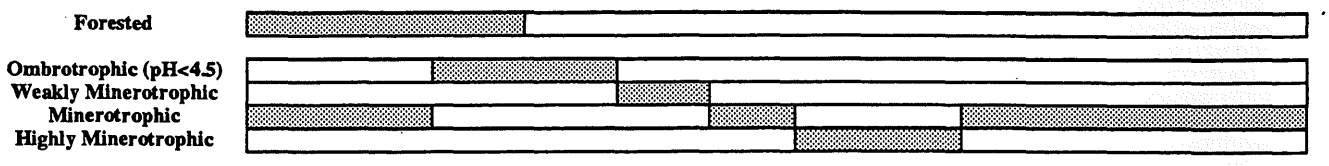
Supplement to Appendix 3. (cont.)



Species	Barrens	Gravel	Bluff	Hill	Mesic	Wet	Saline
Broad-leaved Herbs (cont.)							
Tradescantia bracteata					T?		
Verbena stricta	T?	T	T	T	O		
Vernonia fasciculata						T	
Shrubs							
Amorpha nana (-SE)					T	O	
Ceanothus americanus (-W)	O	O	O	T?	T		
Ceanothus herbaceus (-W)							
Rosa arkansana	?	T	T	T	T?		
Rosa blanda					T?	?	?
Salix humilis (-SW)	T	T	O	?	T		
Spiraea alba						T	
Symphoricarpos occidentalis		T		T	T		

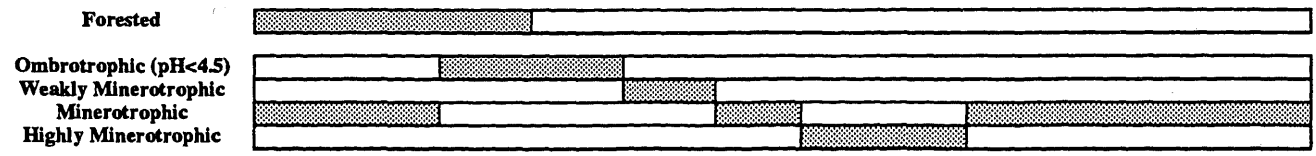
Appendix 4. Common plants of wetland communities in Minnesota, by community in which they occur.

T= typical throughout community range
T(n) = typical in northern Minnesota
T(s) = typical in southern Minnesota
O = occasional, but useful indicator of the type



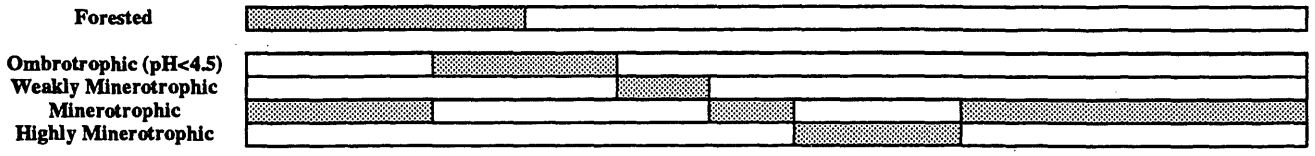
COMMUNITY CLASS	Hardwood Swamp Forest	Conifer Swamp Forest	Bog		Wet Meadow/Fen					Shrub Swamp	Emergent Marsh
COMMUNITY TYPE			Black Spruce Bog	Open Sphagnum Bog	Poor Fen	Rich Fen	Calcareous Seepage Fen		Wet Meadow	Seepage Meadow	
Subtype							Boreal Subtype	Prairie Subtype			
Fraxinus nigra	T										
Acer spicatum	T(n)										
Botrychium virginianum	T(n)										
Circaea alpina	T(n)										
Dryopteris disjuncta	T(n)										
Equisetum sylvaticum	T(n)										
Fragaria virginiana	T(n)										
Mentha arvense	T(n)										
Aralia nudicaulis	T(s)										
Arisamea triphyllum	T(s)										
Betula alleghenesis	T(s)										
Elymus patula	T(s)										
Dryopteris spinulosa	T(s)										
Linnaea borealis	T(s)										
Maianthemum candensis	T(s)										
Mitella nuda	T(s)										
Carex leptalea		T								T(s)	
Carex paupercula		T									
Carex tenuiflora		T									
Lysimachia thrysiflora		T									
Potentilla palustris		T									
Salix pedicellaris		T									
Thuja occidentalis		T					T				
Larix laricina	T(s)	T		T	T		T				
Carex trisperma		T	T								
Gaultheria hispidula		O	O								
Smilacina trifolia		T	T		T						
Vaccinium vitis-idaea		T	T								
Ledum groenlandicum		T	T	T							
Picea mariana		T	T	T							
Chamaedaphne calyculata		T	T	T	T	T					
Drosera rotundifolia		T		T	T		T				
Andromeda glaucophylla		T	T	T	T	T	T				
Vaccinium oxycoccos		T	T	T	T	T	T				
Eriophorum spissum			T	T							
Kalmia polifolia			T	T	T						
Carex oligosperma				T							
Carex pauciflora				T							
Sarracenia purpurea		T		T	T	T	T				
Carex chordorrhiza					T	T					
Scheuchzeria palustris					T	T					
Carex limosa					T	T	T				
Menyanthes trifoliata					T	T	T				
Rhynchospora alba					T	T	T				
Betula pumila		T			T	T	T	T		T(s)	
Carex lasiocarpa					T	T	T				
Carex livida						T	T				
Eleocharis compressa						T	T				
Utricularia intermedia						T	T				
Carex exilis							T				
Cladium mariscoides							T				
Drosera anglica							T				
Parnassia palustris							T				
Scirpus hudsonianus							T				
Utricularia cornuta							T				
Muhlenbergia glomerata							T	T			
Scirpus cespitosus							O	O			

Appendix 4. (cont.)



COMMUNITY CLASS	Hardwood Swamp Forest	Conifer Swamp Forest	Bog		Wet Meadow/Fen					Shrub Swamp	Emergent Marsh
COMMUNITY TYPE			Black Spruce Bog	Open Sphagnum Bog	Poor Fen	Rich Fen	Calcareous Seepage Fen		Wet Meadow	Seepage Meadow	
Subtype							Boreal Subtype	Prairie Subtype			
Andropogon gerardi								T			
Carex interior								T			
Carex prairea								T			
Carex sterilis								O			
Carex tetanica								T			
Cirsium muticum								T			
Eriophorum angustifolium								T			
Hypoxis hirsuta								T			
Lobelia kalmii								T			
Parnassia glauca								T			
Pedicularis lanceolata								T			
Rhynchospora capillacea								O			
Salix candida								T			
Scleria verticellata								O			
Solidago ridellii								T			
Triglochin maritima								T			
Triglochin palustris								O			
Zizia aurea								T			
Caltha palustris								T		T	T(n)
Carex bromides										T	
Hydrocotyle americana										T	
Poa paludigena										T	
Symplocarpus foetidus										T	
Osmunda cinnamomea	T(s)									T	T(s)
Alnus rugosa	T										T
Rhus vernix	T(s)										T(s)
Rubus pubescens	T(n)										T(s)
Cornus stolonifera	T(s)										T
Bromus ciliatus								T			T(s)
Ilex verticillata											T
Lycopus uniflorus											T
Myrica gale											T(n)
Physocarpus opulifolius											T(n)
Polygonum hydropier											T(s)
Rhamnus frangula											T(s)
Salix bebbiana											T(s)
Spiraea alba											T(n)
Stellaria longifolia											T(s)
Impatiens capensis	T(s)								T(s)		T(s)
Rumex orbiculatus									T(s)		T(s)
Asclepias incarnata								T	T(s)		T(s)
Hypericum virginianum									T		T(n) T
Lycopus americanus								T	T		
Eupatorium maculatum								T	T(s)		
Calamagrostis inexpansa								T	T		
Calamagrostis canadensis									T(s)		
Carex stricta									T(s)		
Chelone glabra									T(s)		
Cyperus strigosus									T		
Deschampsia caespitosa									T		
Eleocharis acicularis									T		
Eupatorium perfoliatum									T(s)		
Hypericum majus									T		
Juncus balticus									T		
Juncus dudleyi									T		
Ludwigia palustris									T		
Phalaris arundinacea									T(s)		
Polygonum sagittatum									T(s)		
Ranuculus repens									T		
Rorippa islandica									T(s)		
Thelypteris palustris									T(s)		
Urtica dioica									T(s)		

Appendix 4. (cont.)



COMMUNITY CLASS	Hardwood Swamp Forest	Conifer Swamp Forest	Bog		Wet Meadow/Fen					Shrub Swamp	Emergent Marsh
COMMUNITY TYPE			Black Spruce Bog	Open Sphagnum Bog	Poor Fen	Rich Fen	Calcareous Seepage Fen		Wet Meadow	Seepage Meadow	
Subtype							Boreal Subtype	Prairie Subtype			
Cicuta bulbifera	T(s)								T(s)		T
Carex lacustris									T(s)		T
Scirpus cyperinus									T		T
Sium suave									T		T
Sagittaria latifolia									T(s)		T
Typha latifolia							T				T
Carex aquatalis								T			T
Scirpis acutus								T			T
Calla palustris											T
Acorus calamus											T
Alisma subcordatum											T
Alisma trivale											T
Carex trichocarpa											T
Carex atherodes											T
Carex comosa											T
Carex vulpinoidea											T
Eleocharis elliptica											T
Eleocharis palustris											T
Gylceria grandis											T
Leersia orzyoides											T
Lemna minor											T
Lemna trisculata											T
Phragmites australis											T
Polygonum amphibium											T
Pontederia cordata											T
Potamogeton gramineus											T
Potamogeton sp											T
Salix exigua											T
Scirpus fluviatilis											T
Scirpus paludosus											T
Scirpus validus											T
Scolochloa festucacea											T
Sparganium americanum											T
Sparganium eurycarpum											T
Spirodela polyrhiza											T
Typha angustifolia											T
Utricularia vulgaris											T
Veronica catinata											T
Zizania aquatica											T

Appendix 5. Common species and life-forms of aquatic plants useful in distinguishing natural communities[2]. (These species often occur in marsh pools, but not in wet meadows or fens. All are nonpersistent (sensu Cowardin[3]) and common in Lake Bed and River Bed community types.)

Common Name	Taxonomic Equivalent	Life Form
American lotus	*Nelumbo lutea*	XR
coontail	*Ceratophyllum demersum*	SF
elodea	*Elodea canadensis*	SR
floating-leaved pondweed	*Potamogeton natans*	DR
fragrant white water-lily	*Nymphaea odorata*	FR
greater bladderwort	*Utricularia vulgaris*	SF
greater duckweed	*Spirodella polyrhiza*	FF
Illinois pondweed	*Potamogeton illinoensis*	SR
ivy-leaved duckweed	*Lemna trisulca*	SF
large-leaved pondweed	*Potamogeton amplifolius*	SR
lesser duckweed	*Lemna minor*	FF
liverwort	*Riccia fluitans*	FF
pipewort	*Eriocaulon septangulare*	TR
quillwort	*Isoetes macrospora*	TR
sago pondweed	*Potamogeton pectinatus*	SR
water milfoil	*Myriophyllum sibiricum*	SR
water shield	*Brasenia schreberi*	FR
tape-grass	*Vallisneria americana*	SR
yellow pond-lily	*Nuphar luteum*	FR
yellow water-crowfoot	*Ranunculus flabellaris*	SR

Life Form codes

DR = dimorphic with submergent and floating leaves, rooted
FF = free floating on surface, not rooted, or rooted only after stranding
FR = floating-leaved, rooted
SF = entirely submergent, typically free-floating
SR = entirely submergent (except for flowering shoot), rooted
TR = stiff-leaved submergent, rooted
XR = dimorphic with emergent and floating leaves, rooted

2. Primarily from Eggers, S.D. and D.M. Reed. 1987. Wetland plants and plant communities of Minnesota and Wisconsin. U.S. Army Corps of Engineers, St. Paul, Minnesota.

3. Cowardin, L.M., V. Carter, F.G. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Washington, D.C.

Appendix 6. Species tolerant of bog (ombrotrophic) environments

Species of forested bogs	Species of open bogs	Other species
Areucethobium pusillum	Carex oligosperma	Andromeda glaucophylla
Carex paupercula		Carex pauciflora
Carex trisperma		Chamaedaphne calyculata
Cyprepidium acaule		Drosera rotundifolia
Gaultheria hispidula		Eriophorum spissum
Listera cordata		Eriophorum virginianum
Monotropa uniflorus		Kalmia polifolia
Smilacina trifolia		Larix laricina
Vaccinium myrtilloides		Ledum groenlandicum
Vaccinium vitis-idaea		Picea mariana
		Sarracenia purpurea
		Vaccinium oxycoccus