

Cavity nesting waterfowl in Minnesota

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Introduction

North American cavity nesting waterfowl include Wood Ducks *Aix sponsa*, Common and Barrow's Goldeneyes *Bucephala clangula* and *B. islandica*, Hooded and Common Mergansers, *Lophodytes cucullatus* and *Mergus merganser*, Buffleheads *B. albeola*, and Black-bellied Whistling Ducks *Dendrocygna autumnalis*. Except for the last and Barrow's Goldeneye, all occur regularly in Minnesota during spring and fall migration. Of these, sizable breeding populations of all but the Bufflehead have occurred in the state since settlement times. Dramatic changes in land use and increased abundance of the Wood Duck (Bellrose 1976) have resulted in changes in the relative distribution of the species within the state.

Within Minnesota, the nesting distributions of these species were first described by Roberts (1936) and later by Lee *et al.* (1964). Neither of these reports contains detailed documentation of distribution. Nesting records since 1970 have been compiled by Janssen and Simonson (1984). Roberts (1936) described Wood Ducks as present in summer throughout the state but reported that their numbers had been much reduced. Likewise, Lee *et al.* (1964) indicated that Wood Ducks nested statewide, but principally in the eastern three-quarters of the state. Janssen and Simonson (1984) have, since 1970, documented Wood Duck nesting in 59 of Minnesota's 87 counties. Roberts (1936) considered Hooded Mergansers an infrequent summer resident, but Lee *et al.* (1964) described them as nesting statewide with greatest densities in the north-east. Recent breeding of the Hooded Merganser has been documented in only 23 of 87 counties (Janssen and Simonson 1984). Common Goldeneyes have been described as nesting in north-eastern and north central Minnesota whereas nesting Common Mergansers have been reported to occur primarily in extreme northern and north-eastern areas. Roberts (1936) found no Goldeneye nesting records for the southern half of the state, but presented early records of Common Mergansers nesting in extreme south-western and south-eastern

counties. Janssen and Simonson (1984) described these species as nesting in 11 and 5 northern counties, respectively. Breeding Buffleheads have been recorded in only 2 counties (Davis 1978, Heidel 1983, Bell 1985, Mattsson 1986).

Waterfowl nest box records were used to document further the current breeding distribution of cavity nesting waterfowl in Minnesota, and to quantify their relative abundance in relation to landscape regions within the state.

Study Area

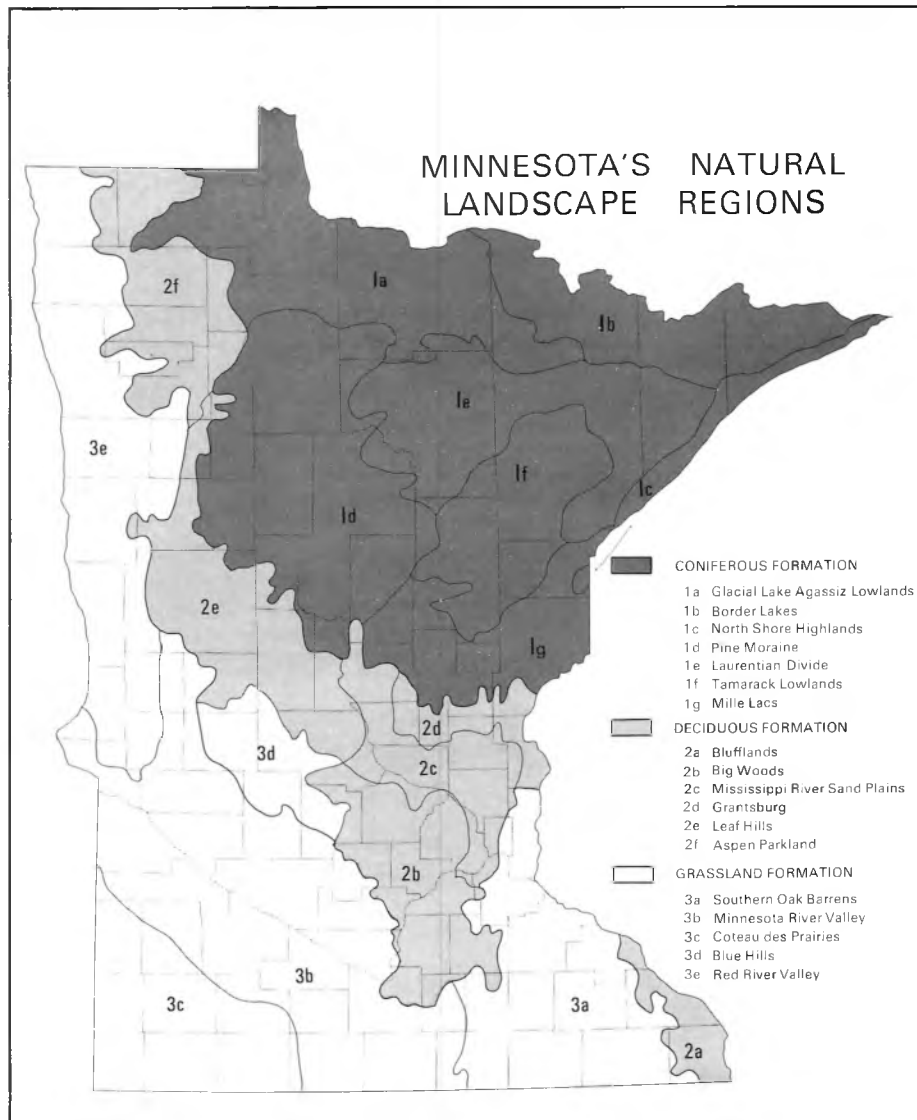
Minnesota's geological history and location at the juncture of the northern coniferous forest, eastern deciduous forest, and tall-grass prairie biomes of North America have resulted in considerable biotic diversity (Marschner 1930). Geomorphology and vegetation vary widely within the 3 formations, and 18 landscape regions have been delineated (Kratz and Jensen, undated) (Figure 1 and Appendix).

Methods

From 1979 to 1985, we collected waterfowl nesting data ourselves and also from cooperators who were working with nest boxes throughout the state. Statewide coverage was incomplete because participation was voluntary. Most boxes were checked in fall and winter, but individual cooperators were consistent from year to year. When possible, histories of individual box use were maintained, but we also used data from boxes that were not identified individually by cooperators. All box locations were identified by township and range land survey coordinates.

To ensure data accuracy each cooperator was furnished with data sheets and descriptions of the eggs, shell fragments and down of the cavity-nesting waterfowl (Bent 1923-25). Shell fragments from Wood Duck, Hooded Merganser, and Common Goldeneye eggs were also provided to cooperators requesting additional help with species identification. Each data sheet was

Figure 1. Minnesota's natural landscape regions



reviewed and waterfowl nesting was recorded if at least 1 egg, shell fragments, abundant down, or a hen were indicated as present. Species were identified only for those nests having identified eggs, shell fragments, or hens reported present. Also cooperators proficiency was measured by selecting four who had different technicians checking boxes each year. From 1981 to 1984, 341 boxes were field-checked in June and July prior to their being examined by cooperators in the fall and winter. Boxes checked by these cooperators sometimes had mixed-species clutches (Bouvier 1974;

M.C. Zicus, unpubl. data), and these boxes served as a good measure of cooperator proficiency.

Results

From 840 to 2,693 functional nest boxes were examined each year (Table 1). Approximately 74% of the boxes were individually identified so their histories could be followed, but not all of these boxes were checked annually. Most of the remaining boxes were also checked each year, but we

Table 1. Number of functional waterfowl nest boxes included in the survey, 1979-85.

Year	With Histories	Without Histories	Total
1979	653	187	840
1980	1,332	303	1,635
1981	1,637	379	2,016
1982	1,799	444	2,243
1983	2,104	577	2,681
1984	1,995	698	2,693
1985	325	786	1,111
Total	9,845	3,374	13,219

could not follow their histories because cooperators did not identify them individually. Because there was little change by year in regional box occupancy rates results were combined for all years.

All 3 formations and 17 of the 18 landscape regions had nest boxes checked (Table 2). Coverage and sampling intensity varied among landscape regions. Generally, landscape regions in the Coniferous Forest were most completely and intensively sampled. The Coniferous Forest Formation included 41% of the state land area, but contained 60% of the boxes checked. Although boxes were examined in more townships (a land survey unit equal to 92.16

Table 2. Minnesota landscape regions having waterfowl nest boxes examined, 1979-85.

Formation/Region	Map Designation	Area (km ²)	Sample (%)a/	Boxes Examined
Coniferous Formation				
Glacial Lake	1a	17,660	10.6	324
Agassiz Lowlands				
Border Lakes	1b	10,060	51.9	1,152
North Shore	1c	2,460	30.3	68
Highlands				
Pine Moraine	1d	21,360	24.9	3,635
Laurentian Divide	1e	14,580	37.1	2,036
Tamarack Lowlands	1f	9,650	20.3	629
Mille Lacs	1g	8,830	8.4	115
Total		84,600	25.1	7,959
Deciduous Formation				
Blufflands	2a	2,220	4.2	14
Big Woods	2b	9,240	2.0	147
Mississippi River	2c	6,780	13.8	912
Sand Plains				
Grantsburg	2d	2,830	3.3	18
Leaf Hills	2e	11,460	4.9	57
Aspen Parkland	2f	9,120	10.2	2,057
Total		41,650	6.7	3,205
Grassland Formation				
Southern Oak	3a	15,030	5.0	230
Barrens				
Minnesota River	3b	28,750	3.9	298
Valley				
Coteau des	3c	10,840	17.2	152
Prairies				
Blue Hills	3d	4,560	NSb/	0
Red River Valley	3e	19,840	9.4	1,375
Total		79,020	7.1	2,055

a/ Percent of townships (92.16 km²) having at least one box examined

b/ Not sampled

km²) in the Grassland Formation than in the Deciduous Forest Formation, more boxes were checked per unit of land area in the Deciduous Forest.

Wood Ducks were the most widely distributed species (Figure 2a) and were most often reported from landscape regions in the Deciduous Forest Formation, followed by the Grassland and Coniferous Forest

formations (Table 3). Wood ducks used a higher proportion of the boxes from the Grantsburg Landscape Region than any other, but few boxes were checked and little area surveyed in this region. The Minnesota River Valley, Mississippi River Sand Plains, Big Woods, Aspen Parklands, and Pine Moraine regions also had high use of nest boxes. No Wood Ducks were reported

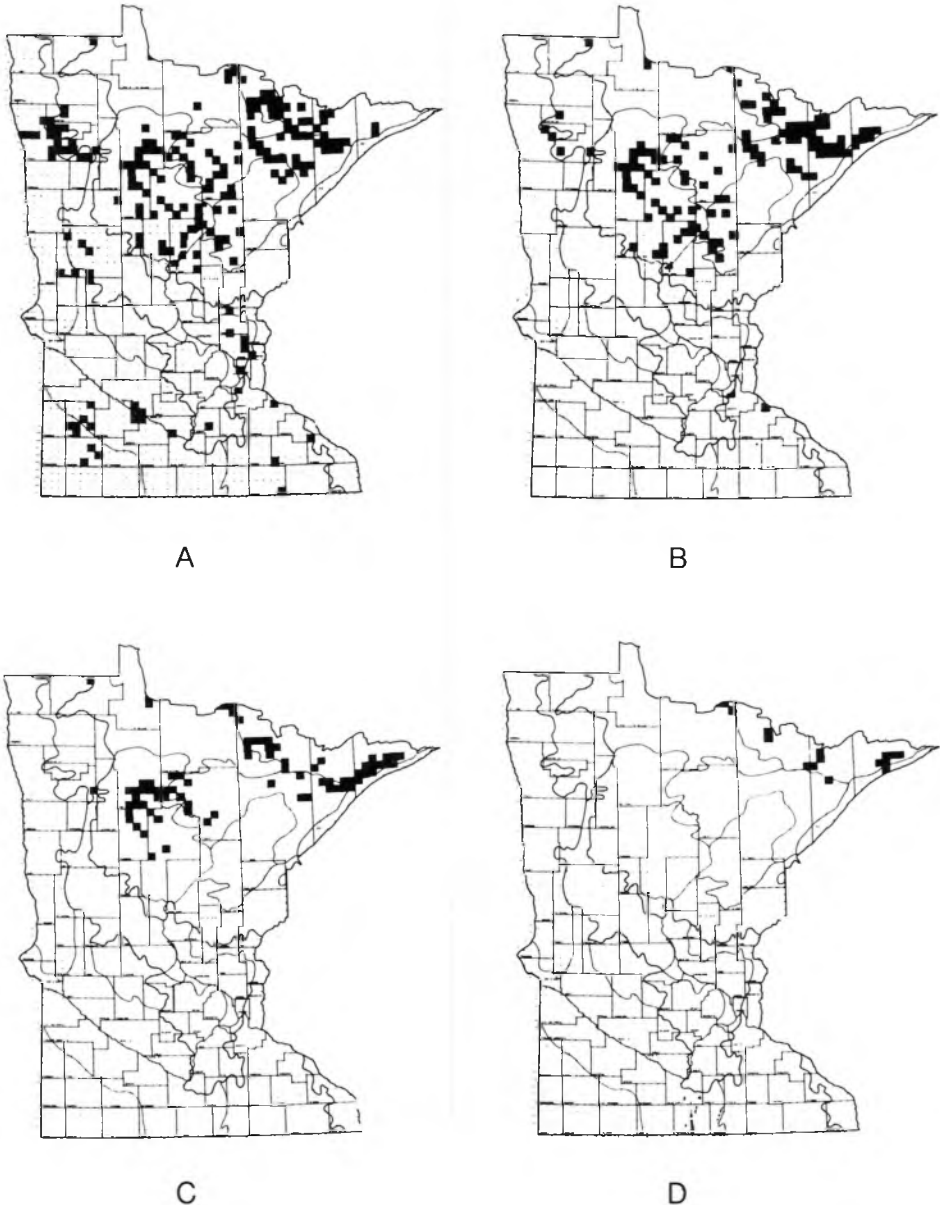


Figure 2. Nesting distribution of Wood Ducks (A), Hooded Mergansers (B), Common Goldeneyes (C), and Common Mergansers (D) in Minnesota, 1979–85.

Table 3. Percent of nest boxes having evidence of waterfowl nesting by Formation and landscape regions, 1979–85.

Formation/Region	Wood Duck	Hooded Merganser	Common Goldeneye	Common Merganser	Mixed Species
Coniferous Formation					
Glacial Lake Agassiz (1a) Lowlands	11.3	3.6	30.8	3.6	4.6
Border Lakes (1b)	9.9	12.2	14.4	1.9	4.1
North Shore (1c) Highlands	0.0	7.0	30.0	1.8	3.5
Pine Moraine (1d)	21.1	12.3	15.2	0.0	3.6
Laurentian Divide (1e)	12.7	9.5	5.0	0.1	1.3
Tamarack Lowlands (1f)	13.2	9.6	0.0	0.0	0.5
Mille Lacs (1g)	13.7	2.0	0.0	0.0	0.0
Average a/	14.0	8.5	13.7	1.0	2.7
Deciduous Formation					
Blufflands (2a)	0.0	0.0	0.0		0.0
Big Woods (2b)	27.2	0.0	0.0		0.0
Mississippi River (2c) Sand Plains	27.4	2.0	0.0		0.0
Grantsburg (2d)	50.0	0.0	0.0		0.0
Leaf Hills (2e)	8.8	0.0	0.0		0.0
Aspen Parkland (2f)	24.5	0.5	0.1		Tr
Average	21.7	0.4	Tr b/		Tr
Grassland Formation					
Southern Oak (3a) Barrens	6.8	3.2			0.0
Minnesota River (3b) Valley	34.2	0.0			0.0
Coteau des (3c) Prairies	3.9	0.0			0.0
Blue Hills (3d)	NS c/	NS			NS
Red River Valley (3e)	15.5	0.8			0.3
Average	19.3	0.9			0.1

a/ Weighted for land area of landscape regions within Formation

b/ Less than 0.05 percent

c/ Not sampled

nesting in boxes from the Blufflands and the North Shore Highlands regions. However, few boxes were checked and little area covered in the Blufflands. Few boxes were also examined in the North Shore Highlands, but 30% of the townships were sampled.

Nesting Hooded Mergansers occurred less widely in the state than did Wood Ducks (Figure 2b). Hooded Mergansers were reported from all Coniferous Forest landscape regions and from 2 landscape regions in both the Deciduous Forest and

Grassland formations (Table 3). Highest box occupancy by Hooded Mergansers was in the Pine Moraine and Border Lakes regions. Within the Coniferous Forest Formation, Hooded Mergansers appeared least abundant in the Mille Lacs and Glacial Lake Agassiz Lowlands landscape regions. They were also reported infrequently in the Deciduous Forest and Grassland formations.

Common Goldeneyes and Common Mergansers nested only in boxes examined in northern Minnesota (Figures 2c and 2d).

Goldeneyes were found in 5 of the 7 landscape regions in the Coniferous Forest Formation, but in only one Deciduous Forest region (Table 3). Goldeneyes were most prevalent in boxes from the relatively poorly sampled Glacial Lake Agassiz Lowlands and the North Shore Highlands landscape regions. In comparison, Common Mergansers had the most limited distribution of the 4 species encountered, and were restricted to 4 landscape regions in the Coniferous Forest Formation. Common Mergansers were most abundant in the Glacial Lake Agassiz Lowlands Region, but were limited to the very large lakes along the northern edge of this region where most sampling occurred.

Evidence of interspecific nest parasitism was observed in all 3 formations, but was most common in the Coniferous Forest where all 4 species occurred (Table 3). With the exception of the Common Merganser, nests containing all possible combinations of the other 3 species were reported. Common Merganser eggs were found in nests also containing Common Goldeneye eggs. Of 206 multiple-species nests observed in boxes in the Coniferous Forest Formation, 75% involved Hooded Mergansers, 64% Goldeneyes, 61% Wood Ducks, and 3% Common Mergansers. These nests included both those incubated by one or another species and nests that were abandoned.

Discussion

Present waterfowl surveys in Minnesota do not adequately monitor cavity nesting waterfowl populations. In general, these species are difficult to survey because of the forested habitats they occupy and the inconspicuousness of Wood Ducks and Hooded Mergansers. Zicus and Hennes (1987) indicated nest box occupancy could be used to index changes in breeding populations and production for these species, but measures of absolute or relative numbers across large areas are much more difficult to obtain. Nest boxes currently also provide the best insight into the relative proportions of cavity nesting waterfowl breeding in Minnesota's various landscape regions, but these data may contain unmeasurable biases.

Zicus and Hennes (1987) indicated that identification proficiency by cooperators was good, but not perfect. Multiple species egg-laying in the same box was common in

the Coniferous Forest Formation and may have been underestimated for those nests that were successfully incubated. Cooperators sometimes failed to detect the shell fragments from 1 or 2 hatched eggs that differed from the rest of the clutch. Bias also existed relative to the time of year nest boxes were inspected. Detection of waterfowl nesting decreased as the time between nesting and nest box inspection increased. Although some cooperators inspected boxes during the nesting season, most examined them during fall and winter (all were individually consistent as to when they checked boxes). Thus, in most locations waterfowl nesting may have been underestimated.

Differences in disappearance rates of nesting evidence could also bias results. Whereas eggs of the cavity nesting waterfowl vary in size and shell thickness (Bent 1923–25), preliminary work suggested that unhatched eggs did not disappear differentially among species. It is possible, however, that eggshell chips in hatched nests may disappear at different rates for different species, and yearly differences in the detection of all shell fragments may exist as well.

All 4 species we encountered will nest in man-made boxes, but a species-related propensity to use boxes may also exist. Prince (1968) described some differences in characteristics of natural cavities used by Wood Ducks and Common Goldeneyes, but these may have reflected differences in the forest stands he examined and not actual selection. Lumsden *et al.* (1980) demonstrated that Common Goldeneyes selected boxes having specific characteristics, but could not demonstrate a selection difference between Goldeneyes and Hooded Mergansers. Later work, although inconclusive, suggested there may be species-related preferences for boxes with different hole sizes (Lumsden *et al.* 1986). We know of no measurements of the relative preference for natural cavities versus man-made nest boxes among the various species. Most of the boxes we surveyed were made of wood and had the same dimensions (30 cm x 25 cm x 60 cm) and the same size entrance holes (7.5 cm x 10 cm). However, some cooperators in the north used boxes with larger entrances to accommodate Common Mergansers. Our estimates of relative abundance will be biased if a particular box construction or physical placement is pre-

ferred by one species more than another. Nest boxes with smaller entrances will exclude Common Mergansers (Henderson 1984), and this factor, combined with the species' habit of also nesting on the ground, no doubt caused the abundance of Common Mergansers to be underestimated relative to other species.

Habitat types within a landscape region were not all sampled at random thus introducing another bias source to the data. Because landscape regions were defined by glacial geology, soils, climate, and resulting vegetation, variation due to habitat should generally be greater among landscape regions than within. However, this may not have been true because of the specific habitats in which boxes occurred. We recognise the greatest bias probably existed for landscape regions within the Grassland Formation. A large portion of this formation is unforested agricultural land (Minnesota State Planning Agency 1975) and wetland densities are generally lower in much of the formation than the remainder of the state (Minnesota Department of Conservation 1968). Only habitats associated with streams, rivers, lakeshores, and other wetlands were sampled, and thus the data did not adequately represent the formation as a whole.

Despite the biases, these data increase knowledge of the current nesting distribution of these species and provided the best available measures of the relative proportions of cavity nesting waterfowl breeding in Minnesota's various landscape regions. Wood Duck nesting was documented in 10 additional counties, Hooded Mergansers in 9, Common Goldeneyes in 4, and Common Mergansers in 1 county not listed in the Janssen and Simonson (1984) compilation.

Wood Ducks appeared to be most abundant in those landscape regions having extensive deciduous forest types associated with numerous lakes or low gradient streams regardless of the formation. Although few boxes were surveyed in the Grantsburg Region, we believe the high box occupancy observed is a reflection of abundant breeding birds. Janssen and Simonson (1984) reported Wood Duck nesting in 5 of 7 counties partially included in this region. In contrast, our limited sampling did not document any breeding Wood Ducks in the Blufflands although Janssen and Simonson (1984) reported the species from all counties in and adjacent to

the region. Lastly, our North Shore Highlands sample was small but included 30% of the region's townships, and the lack of breeding Wood Ducks observed along the north shore of Lake Superior was probably real. The other species had comparatively more restricted distributions, but were relatively abundant in certain regions. Hooded Mergansers appeared most common in those landscape regions having the highest lake and stream densities if forest cover was also extensive. Common Goldeneyes were more restricted, being found primarily in Coniferous Forest landscape regions having relatively large lakes. Common Mergansers were the most specific, nesting in those landscape regions in the Coniferous Forest Formation that were associated with Lake Superior or the large Pre-Cambrian rock-bound lakes along the Canadian border.

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Summary

Cavity nesting waterfowl pose difficult census and survey problems. A total of 13,219 waterfowl nest box checks from 1979 to 1985 were used to document further the current breeding distribution of cavity nesting waterfowl in Minnesota and to estimate their relative abundance in relation to 18 landscape regions. Wood Duck nesting was documented in 10 additional counties and was most common in the Deciduous Forest Formation. In comparison, Hooded Mergansers, Common Goldeneyes, and Common Mergansers were most common in the Coniferous Forest Formation. These 3 species were documented as nesting in 9, 4, and 1 counties respectively, not listed by Janssen and Simonson (1984). Continued efforts to improve measures of the distribution and relative abundance of cavity nesting waterfowl in relation to land-use patterns will further our understanding of their ecology and improve their management.

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Appendix

Coniferous Forest

Coniferous, deciduous, and mixed coniferous-deciduous forests cover the north-eastern two-fifths of the state (Buell and Niering 1957). Conifers (*Pinus* spp., *Abies* sp., *Picea* spp.) are predominant in the north and deciduous trees (*Betula* spp., *Populus* spp., *Tilia* sp., *Acer* sp.) more common in the south. Human impact in most of these regions has been low to moderate.

Glacial Lake Agassiz Lowlands (1a). Once covered by Glacial Lake Agassiz, this region has extensive peatlands supporting conifer bogs, swamps, and large areas devoid of trees (Heinselman 1970). Lake and stream densities are low.

Border Lakes (1b). Characterised by numerous mesotrophic to oligotrophic lakes amidst ridges of exposed bedrock supporting coniferous forest, much of this region is designated National Forest, Wilderness Area, or National Park.

North Shore Highlands (1c). Rising abruptly 250–500 m above Lake Superior, this region has few lakes but many high gradient rivers flowing directly into the lake, and supports coniferous and mixed deciduous-coniferous forests.

Pine Moraine (1d). This otherwise level region is bisected from east to west by the elevated Itasca Moraine. Presettlement pine forests have been replaced by mixed coniferous-deciduous forests. Numerous small lakes occur in the moraine where the Mississippi River originates, with larger lakes in the lowlands to the north.

Some forest clearing for agriculture has occurred in the west.

Laurentian Divide (1e). An east-west formation of iron-bearing rock, and a low parallel ridge of irregular hills forming a major watershed divide, characterise the region. Lakes are numerous in the west but fewer in the east. Vegetation is primarily mixed coniferous-deciduous forest. The landscape has been extensively altered by open-pit iron mining.

Tamarack Lowlands (1f). This region has extensive peatlands with scattered deposits of mineral soil. Mixed coniferous-deciduous forest and conifer bog and swamp are the most abundant vegetation. Lake density is low to moderate.

Mille Lacs (1g). The extensive presettlement pine forest of this region has been largely replaced by mixed deciduous-coniferous forest. Lake density is low to moderate, but there are many low gradient streams in the east.

Deciduous Forest

Deciduous forests (*Ulmus* spp., *Acer* spp., *Tilia* sp., *Quercus* spp., *Populus* spp.) extend from the north-west to the south-east and once comprised about one-fifth of Minnesota. Forest clearing for agriculture and urban areas has been moderate to extensive in these regions.

Blufflands (2a). This unglaciated region is deeply dissected by river valleys and characterised by steep bluffs. Previously forested bluffs and valley bottoms are now cultivated and many hillsides are pastured. The region has few lakes but many high gradient streams.

Big Woods (2b). Presettlement vegetation was primarily climax elm-maple-basswood forest (Daubenmire 1936). Clearing for agriculture and part of the Minneapolis-St Paul metropolitan area has been extensive. Lake density is relatively high.

Mississippi River Sand Plains (2c). These flat to gently rolling sandy outwash plains also include part of the Minneapolis-St Paul metropolitan area. Marshes and lakes are numerous. The presettlement vegetation was predominantly oak savanna.

Grantsburg (2d). Occupying a portion of the Glacial Lake Grantsburg lakebed, the presettlement vegetation was primarily climax maple-

basswood. Today most of the region is in agricultural use. Lake densities are low.

Leaf Hills (2e). A large moraine complex with relatively high relief and many lakes in the west, the region is more rolling and has fewer lakes to the east. Much of the presettlement maple-basswood forest is now farmland.

Aspen Parkland (2f). Formerly covered by Glacial Lake Agassiz, this region is a transition between prairie and coniferous forest. Characterised by a fire-maintained mosaic of prairie and aspen groves, there are few lakes but many shallow wetlands.

Grassland

Grasslands covered the western and southern two-fifths of Minnesota. Few remnants of presettlement prairie remain in these intensively cultivated agricultural regions. Deciduous trees (*Salix* spp., *Acer* spp., *Ulmus* spp., *Populus* spp.) occur primarily in river valleys and along lake margins.

Southern Oak Barrens (3a). This level to gently rolling transition between the prairie and deciduous forest, which was once tallgrass prairie interspersed with oak savanna, has few lakes or wetlands.

Minnesota River Valley (3b). This undulating till plain is divided by the Minnesota River Valley. The area is dotted with marshy depressions, many of which have been drained.

Coteau Des Prairies (3c). A massive plateau separated from the Minnesota River Valley region by an escarpment rising approximately 200 m above the plain, the region is gently to steeply rolling with lakes occurring along the escarpment.

Blue Hills (3d). A rugged, hilly moraine interspersed with small lakes and marshes in the west, the region becomes a level to slightly rolling outwash plain with numerous small marshes in the east. Deciduous woodlands occur primarily in the western portion.

Red River Valley (3e). Once covered by Glacial Lake Agassiz, the Red River drains this region to the north. The topography is flat in the west and becomes gently undulating to the east. Prairie wetlands are numerous in the east.