

Chapter 3: Refuge Environment

Introduction

Tamarac NWR encompasses 42,738 acres of land and waters in the glacial lake area of northwestern Minnesota. The Refuge is located in Becker County, 18 miles northeast of Detroit Lakes, in the heart of one of the most diverse ecological transition zones in North America, where northern hardwood forests, coniferous forest and tall grass prairie converge. Between 10,000 and 10,500 years ago, receding glaciers left behind the rolling ridges and deep depressions that became a woodland area complemented by lakes, rivers, bogs and marshes and is now Tamarac NWR. The primary ecological drivers influencing the plant and wildlife populations of the Refuge are the climate, hydrology, and natural disturbances such as fire, disease and wind events.

Other Units Administered

Wilderness Area

The Tamarac Wilderness Area was established by law in 1976. The Wilderness Area is managed under the provisions of the 1964 Wilderness Act as a unit of the National Wilderness Preservation System. That is, it is “an area where the earth and its community of life are untrammelled by man, where man himself is a visitor who does not remain” (The Wilderness Act, September 3, 1964; (16 U.S.C. 1121 (note), 1131-1136)). Staff carries out no active management in the Tamarac Wilderness Area, but does conduct research in the unit. The management strategy for the wilderness area calls for passive management with natural succession allowed to take its course. In theory, examples of almost all forest types on the Refuge would be preserved in this one single complex of wilderness.

Wilderness Review

As part of the CCP process, we reviewed other lands within the legislative boundaries of Tamarac NWR for wilderness suitability. No additional lands were found suitable for designation as defined by the Wilderness Act of 1964. Many of the lands have been substantially altered by humans, both before



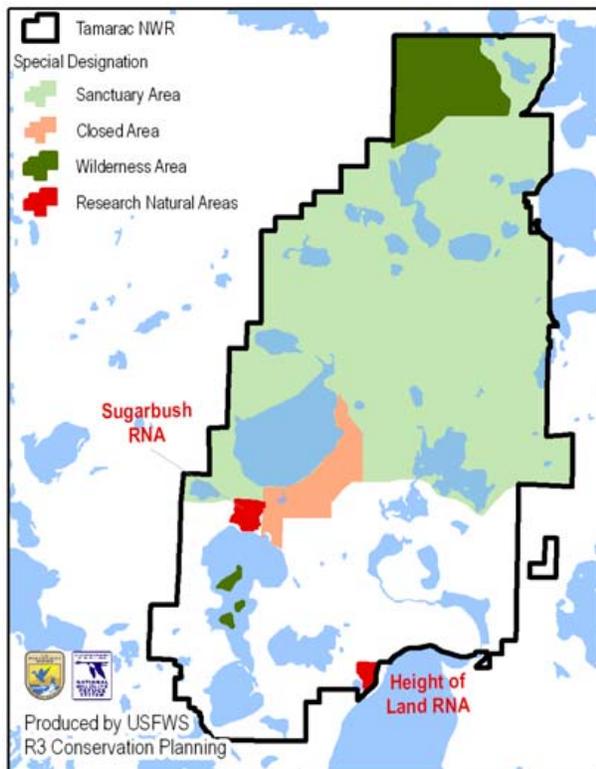
Frog. Photo Credit: Michele Gedgaud

and after the Refuge’s establishment, particularly from agriculture, timber harvest, roads, and water control. Although Tamarac NWR cannot be described as pristine, it is largely an intact, health and functioning ecosystem that just does not meet the strict definition of suitable lands.

Areas of Special Designation

The Research Natural Areas were designated in 1972 with some general management and protection criteria. Research Natural Areas are managed to maintain the natural features for which they were established and to maintain natural processes; therefore, management of the Refuge RNAs is through protection against activities which directly or indirectly modify ecological processes or alter the type or feature which is being preserved. Manipulative practices such as grazing, prescribed burning, timber cutting, road construction and the use of chemical for plant, insect and disease control are not permitted unless such are necessary to maintain the type or process for which the RNA was established or to prevent the spread of insects and disease. There is not a lot of flexibility to manage the wilderness area or RNAs in regard to habitat management; however, there remains a tremendous amount of flexibility in the strategies and tactics that can be

Figure 2: Areas of Special Designation, Tamarac NWR



used to manage these areas (ie: fire suppression tactics, invasive species control, etc.).

The area bordered by the Blackbird Auto Tour and County Highways 29 and 26 was internally designated as an “Old Growth Area” in the early 1990s. The goal was to set aside a significant habitat block in addition to the Wilderness Area and RNAs that would be allowed to develop and be managed for characteristics of old growth forest. Prescribed fire was not excluded as a management tool, but large scale timber harvests would not be allowed. Silvicultural treatments would be used to create small canopy gaps of up to one acre in size to replicate wind throw events.

There is also a significant area designated as sanctuary for the benefit of breeding birds (Figure 2). The lower one-third of the Refuge supports visitor use activities and the sanctuary occupies the northern two-thirds of the Refuge. The sanctuary is closed to the general public from March 1 to September 1 each year. Approximately the northern half of the Refuge lies within the original boundary of the White Earth Reservation, which was established in 1867.

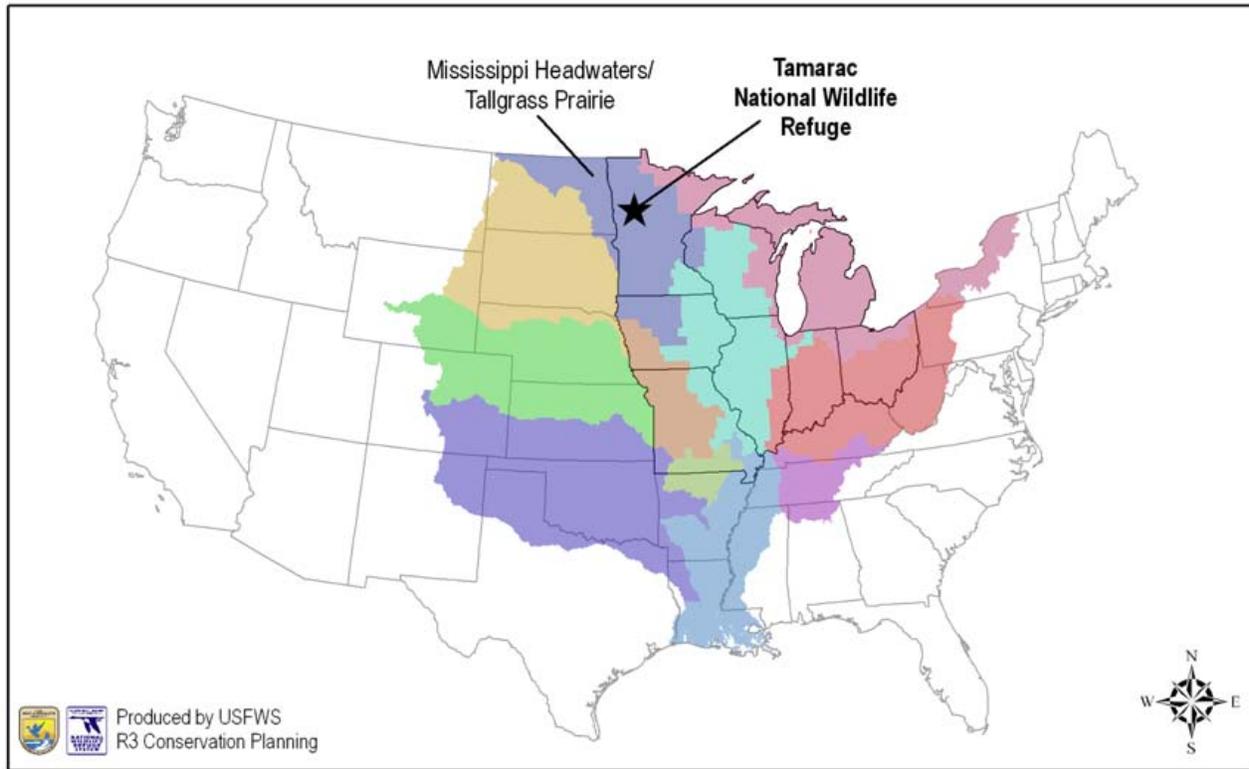
Ecological Context

Situated along the backbone of Minnesota, the Refuge lies within a mile of the continental divide, which separates the Mississippi and Hudson Bay watersheds. Lake Itasca, the headwaters of the Mississippi River, lies approximately 25 miles northeast of the Refuge. Many Refuge lakes and rivers contain large wild rice or “manoomin” beds that produce abundant waterfowl food in most years. Upland vegetation is diverse due to the Refuge’s location in the transition zone between northern hardwood and coniferous forests, which levels off into tallgrass prairie, or the Red River Valley, a mere 10 miles west of Tamarac NWR (Figure 3 on page 14). Hence, many species of plants and animals are at the extreme western edge of their range.

Historic Land Cover

Over thousands of years, the area’s vegetative communities have undergone perpetual change, primarily due to climatic changes following glaciation. “Pollen core” records and pre-settlement conditions are often the best or only sources of information on pristine, baseline conditions and natural environmental and biotic variability. This information is sometimes used as a reference of available vegetation at the various time periods. Pollen core records provide a long-term context of what the landscape was like since the time of the last glaciation, but are often limited in availability (Tester 1995). The pre-settlement vegetation represents a “snap-shot” in the time of the era immediately prior to European settlement within the area and by itself it does not adequately represent changes in vegetative communities and their associated processes over time.

Pollen records from Itasca State Park, which had the same glacial history and climate as the Refuge due to its proximity, indicate transition in dominant plant community types since the retreat of the Wisconsin glacier (Tester 1995). Immediately following this retreat, the land was likely barren and void of vegetation; however, within a few years coniferous trees such as spruce and pine began to dominate the landscape due to the cool and moist environment. These forests dominated the landscape until about 8,000 years ago, when more herbaceous species became prevalent. This indicates the presence of a savanna with scattered oak trees and large open areas of prairie due to warmer and drier conditions. Other studies indicate this warmer, drier period was characterized by extremely variable climatic conditions from drought to abundant precipitation (Almendinger 1988). Several thousand years later, the area became cooler and wetter again, giving rise to an expansion of the coniferous forest (primarily red and white pine) and other deciduous trees back into the area with a decrease of prairie. This condi-

Figure 3: Ecoregion of Tamarac NWR

tion has persisted until the present, with some increase in hardwoods in recent years. Peatlands formed approximately 3,000 years ago. These pollen core records provide a testament to the range of natural variability of vegetation within the larger landscape.

When Euro-American settlers first arrived in Minnesota in the mid-1800s, native plant communities occurred in complex patterns across the entire landscape. Francis Marschner (1882-1966) mapped the pre-European settlement vegetation of Minnesota based on Public Land Survey notes and landscape patterns. His maps provide a reference condition of the vegetation in the area of Tamarac NWR prior to European settlement. Caution should be used when interpreting these historic vegetation maps because of the scale and base data that Marschner used, but it does provide a good context of historic forest types. Based upon Marschner's interpretation for the area that is now Tamarac NWR, pre-European settlement cover types were comprised of mature stands of red and white pine, jack pine barrens, aspen-birch, mixed hardwoods, conifer bogs, swamps and numerous lakes (Figure 4 on page 15). After more than a century of extensive settlement and development, the vast majority of native plant communities within the state have been

destroyed or substantially altered. Although forested communities have changed in composition across much of northern Minnesota following nearly 150 years of logging, opportunities exist for sustainable management and conservation of forested communities in large areas.

Minnesota Ecological Classification System

Recently, the Minnesota DNR established an Ecological Classification System (ECS) for land classification and ecological mapping for Minnesota based upon the national hierarchy of nested units (ie: Provinces, Sections, Subsections, Land Type Associations, etc.). The vegetation classification is hierarchical with units describing broad landscapes to local native plant communities (NPC). The Minnesota ECS enables land managers to consider ecological patterns for broad landscapes or for a single small local unit, (ie: forest stand or native plant community) which is valuable at multiple planning levels and crucial to the long-term ecological integrity and stability of these ecosystems. One of the most important considerations in the ECS classification is the inclusion of ecological processes as an organizing principle (e.g., fire regime, successional or seral stage, hydrology, etc.). In order to facilitate habitat management and restoration, an assessment of cur-

Figure 4: Vegetation of Tamarac NWR and Becker County Prior to European Settlement

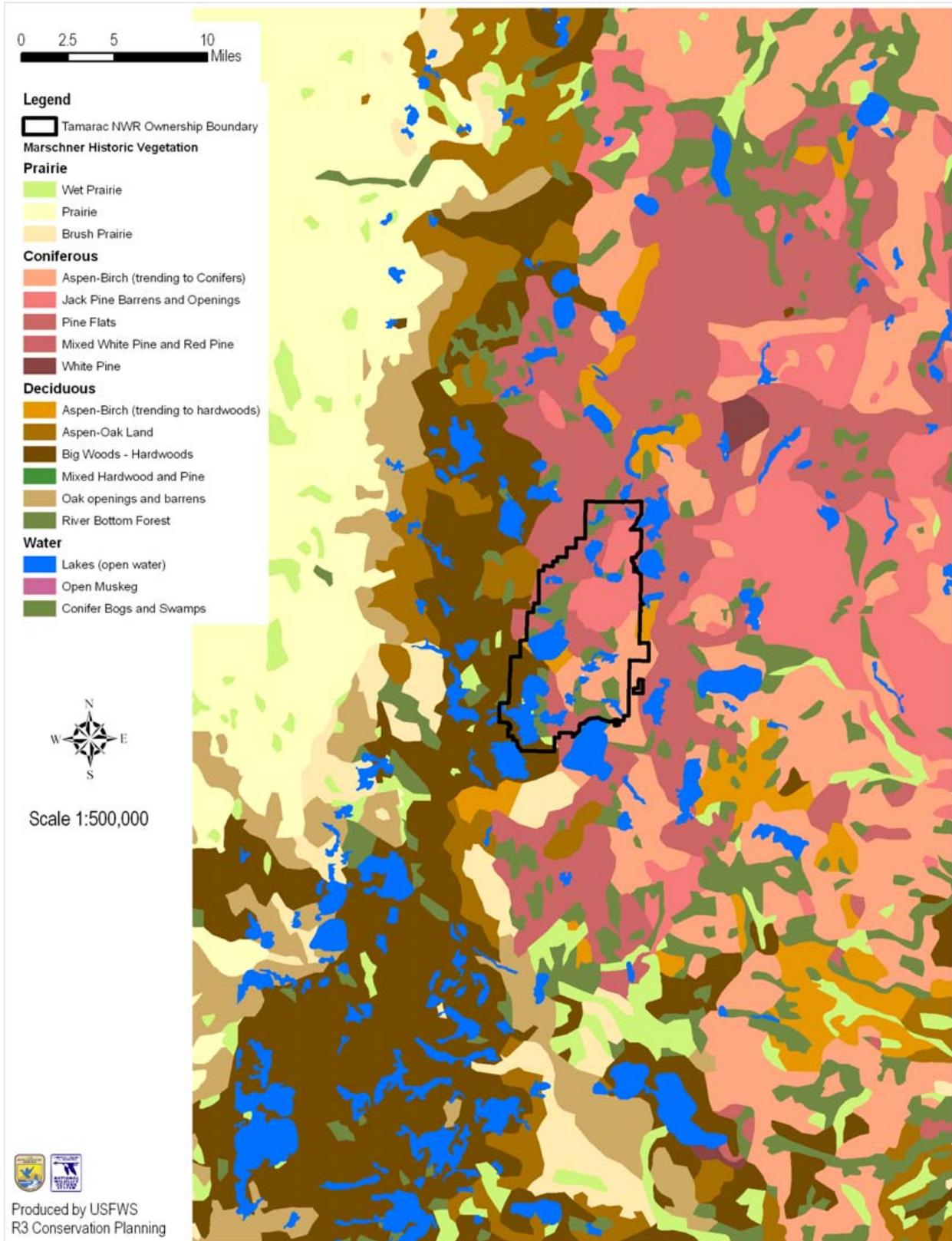
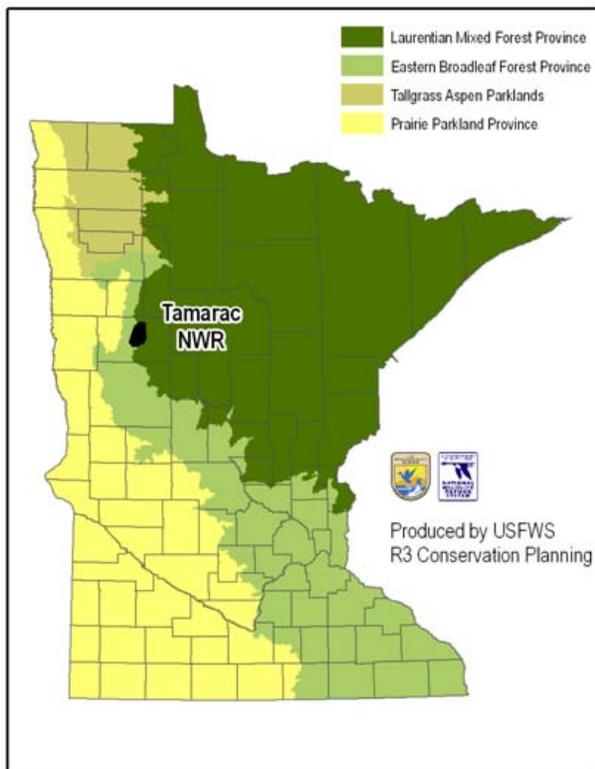


Figure 5: Tamarac NWR in Relation to Major Provinces of Minnesota



rent conditions including disturbance regimes, successional pathways, rare communities, common plant/animals and habitats, invasive species, water resources, and soils is imperative. The comparison of current conditions to historical and desired future conditions is crucial in the development and refinement of management goals, objectives and strategies.

Provinces are the highest level of classification under the Minnesota ECS. These provinces were defined using major climate zones, native vegetation and biomes such as prairies, deciduous forests and boreal forests. The four major provinces of Minnesota include the Laurentian Mixed Forest, Eastern Broadleaf Forest, Prairie Parkland and the Tallgrass Aspen Parklands. Tamarac NWR falls primarily in the Laurentian Mixed Forest with the exception of a small sliver along the southwestern edge of the Refuge, which falls in the Eastern Broadleaf Forest (Figure 5). Tamarac NWR lies near the tallgrass prairie province but is clearly within a forest landscape.

Sections are units within provinces that are defined by origin of glacial deposits, regional elevation, distribution of plants and regional climate.

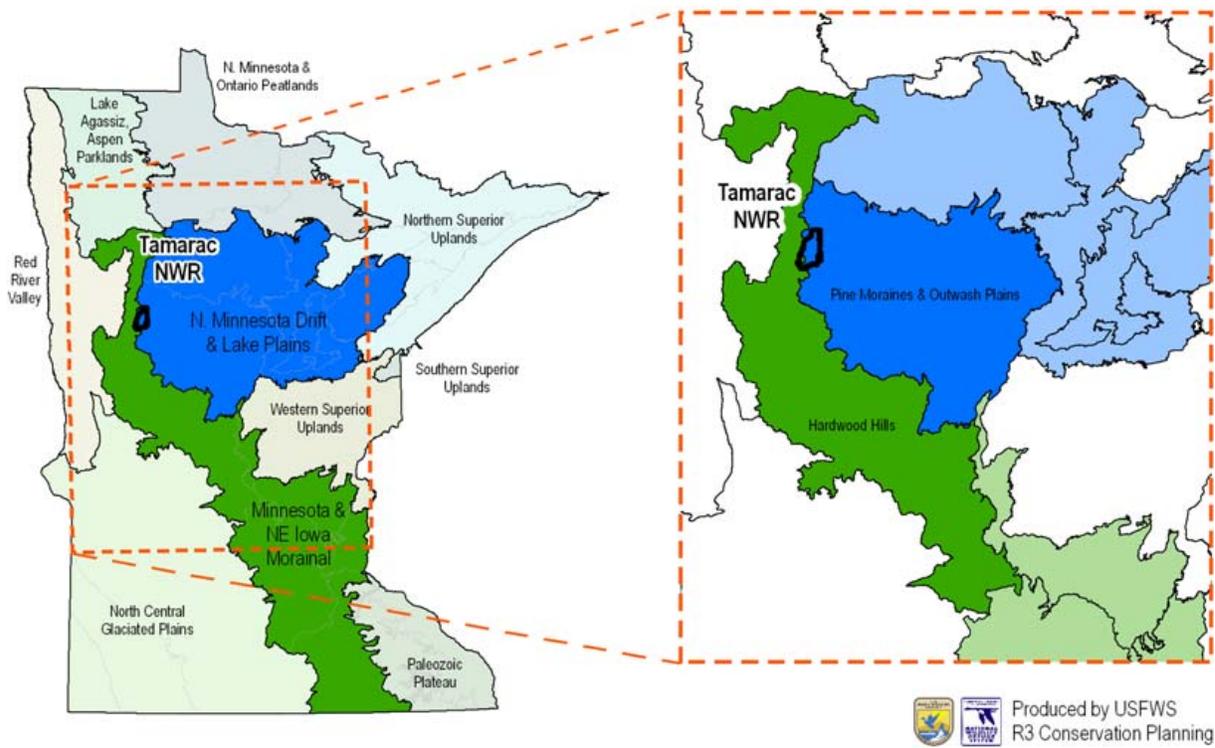
Tamarac NWR falls primarily within the Northern Drift and Lake Plains section, with a small sliver falling in the Minnesota and Northeast Iowa Morainal (Figure 6).

Subsections are units within sections that are defined using glacial deposition processes, surface bedrock formations, local climate, topographic relief and the distribution of plants, especially trees. Tamarac NWR falls primarily with the Pine Moraines and Outwash Plains subsection, and a small portion in the Hardwood Hills subsection. The subsection level will be the primary reference for landscape level planning. The Pine Moraines and Outwash Plains subsection should be the primary reference for planning as greater than 97 percent of the Refuge falls within this subsection. Considerations for the Hardwood Hills subsection should be restricted to the extreme southwestern corner of the Refuge, along the west side of Tamarac Lake.

The Pine Moraines and Outwash Plains Subsection is characterized by the mix of end moraines, outwash and till plains, abundant lakes and wetlands, and large, heavily forested tracts. Kettle lakes and wetlands are common on the outwash plains (Minnesota DNR 2006). Before this area was settled by people of European descent, forests of jack pine mixed with northern pin oak were most common on excessively drained portions of broad outwash plains, and aspen-birch and pine (mixed red and white) forests were the most common on the irregularly sloped end moraines (Figure 6 on page 17). Mixed hardwood and pine forests, dominated by a diverse mix of northern hardwoods and white pine, were found in the most fire-protected areas at the northern and eastern edges of the subsection. Fire occurred on a 10- to 40-year interval within much of the subsection, accounting for the dominance by upland conifers and quaking aspen-birch forests (Frissel 1973); however, natural fire protection was provided by irregular topography, broad wetlands, and relatively large lakes. Forest management and tourism are the predominant land uses within this area today; however, agriculture is becoming more common. Near-shore habitat is being lost at a rapid pace due to increased development along lakes, thus negatively affecting fish and wildlife.

The Hardwood Hills Subsection is characterized by many wetlands, prairie potholes, and kettle lakes exist throughout the area. Before settlement by people of European descent, vegetation included maple-basswood forests interspersed with oak savanna, tallgrass prairie, and oak forest, but the topography and distribution of lakes and wetlands provided a partial barrier to fire that resulted in woodlands rather than prairie vegetation. Fire was important in oak savanna development, whereas, windthrow was common in the sugar maple-bass-

Figure 6: Tamarac NWR in Relation to Sections and Subsections of the Ecological Classification System of Minnesota



wood forests. Currently much of this subsection is farmed and many wetlands have been drained. Important areas of forest and prairie exist throughout the subsection, but they are small and fragmented. Development, tourism, and outdoor recreation, especially around lakes, are other significant land uses that are impacting wildlife within this subsection.

Migratory Bird Conservation Initiatives

Several migratory bird conservation plans have been published over the last decade that can be used to help guide management decisions for refuges. Bird conservation planning efforts have evolved from a largely local, site-based orientation to a more regional, even inter-continental, landscape-oriented perspective (Figure 7 on page 18).

Several trans-national migratory bird conservation initiatives have emerged to help guide the planning and implementation process. The regional plans relevant to Tamarac NWR are:

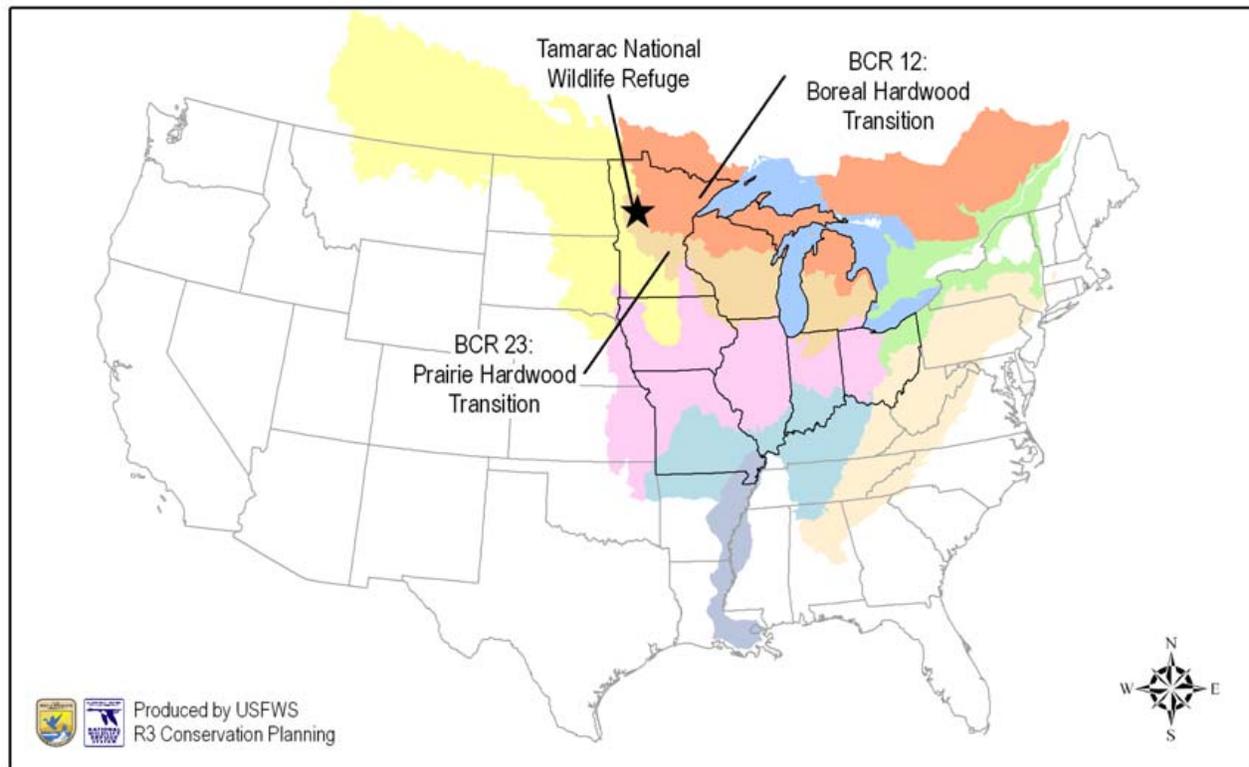
- The Upper Mississippi River/Great Lakes Joint Venture Implementation Plan of the North American Waterfowl Management Plan;

- The Partners in Flight Boreal Hardwood Transition [land] Bird Conservation Plan;
- The Upper Mississippi Valley/Great Lakes Regional Shorebird Conservation Plan; and
- The Upper Mississippi Valley/Great Lakes Regional Waterbird Conservation Plan.

All four conservation plans will be integrated under the umbrella of the North American Bird Conservation Initiative. Each of the bird conservation initiatives has a process for designating priority species, modeled to a large extent on the Partners in Flight method of computing scores based on independent assessments of global relative abundance, breeding and wintering distribution, vulnerability to threats, area importance, and population trend. These scores are often used by agencies in developing lists of priority bird species. The Service based its 2001 list of Non-game Birds of Conservation Concern primarily on the Partners in Flight, shorebird, and waterbird status assessment scores.

Minnesota Comprehensive Wildlife Conservation Strategy

In 2005, Minnesota completed the Comprehensive Wildlife Conservation Strategy (CWCS), a stra-

Figure 7: Bird Conservation Regions Related to Tamarac NWR

tegic plan to better manage populations of “species in greatest conservation need” in Minnesota. The plan was developed with the support of funding from the State Wildlife Grant Program created by Congress in 2001. The heart of the strategic plan is for a partnership of conservation organizations across Minnesota to work together to sustain the populations of the identified species. Members of the partnership include the Minnesota Department of Natural Resources, the U.S. Fish and Wildlife Service, The Nature Conservancy, Audubon Minnesota, and the University of Minnesota, as well as many other agencies and conservation organizations. The plan outlines priority conservation actions that might be undertaken by partners.

Midwest Region Fish and Wildlife Conservation Priorities

Every species is important; however the number of species in need of attention exceeds the resources of the Service. To focus effort effectively, Region 3 of the Fish and Wildlife Service compiled a list of Resource Conservation Priorities. The list includes:

- All federally listed threatened and endangered species and proposed and candidate species that occur in the Region.

- Migratory bird species derived from Service wide and international conservation planning efforts.
- Rare and declining terrestrial and aquatic plants and animals that represent an abbreviation of the Endangered Species program’s preliminary draft “Species of Concern” list for the Region.

Appendix D lists Regional Resource Conservation Priority species relevant to Tamarac NWR and WMD.

Landscape Connectivity and Corridors

Forests throughout North America are becoming increasingly fragmented and in some cases isolated. Fragmented and isolated forests tend to take on characteristics of habitat islands unless corridors and connectivity to larger blocks of forest are maintained. Ultimately, biotic diversity is lost over time within these isolated forests. Tamarac NWR’s position near the edge of three major biomes, coupled with increasing development by humans, makes it extremely susceptible to isolation from the rest of the forest province extending into Minnesota from northeastern North America. The Ponsford Prairie

is an open landscape to the east of the Refuge that was once historically a forested area. If development or agriculture were to expand to the northwest or southwest from the Ponsford Prairie it could threaten Tamarac NWR's connectivity to the rest of the intact forest.

If Tamarac NWR intends to maintain the biological integrity, diversity and environmental health, it is imperative that connectivity is maintained to the forested ecosystems of Minnesota. Refuge staff has discussed the possibility of maintaining the connectivity to other natural resource land management areas such as Itasca State Park, Chippewa National Forest, state forests (White Earth, Two Inlets, Smoky Hills), wildlife management areas (Hubbel Pond), county and tribal lands through corridors, conservation easements and stewardship planning with both land management agencies and private landowners.

Other Conservation Lands in the Area of Tamarac NWR

The Refuge is an integral part of a significant complex of federal, state, tribal and county lands administered for natural resources (Figure 8 on page 20). The Minnesota Department of Natural Resources manages the 3,342-acre Hubbel Pond Wildlife Management Area (WMA), which borders the Refuge to south, the Greenwater Lake Scientific and Natural Area, Itasca State Park, and three large state forests (White Earth, Two Inlets and Smoky Hills) that lie within 25 miles of the Refuge to the east. Many other small state WMAs lie within short distance of the Refuge as well. The Becker County Natural Resources Department is responsible for managing the county's nearly 75,000 acres of tax-forfeited lands, most of which lie within the eastern half of the county. A significant portion of this tax-forfeited land lies along the northwestern boundary of the Refuge. The northern half of the Refuge lie within the White Earth Reservation, although most of the land adjacent the Refuge in not in tribal ownership. The Chippewa National Forest, which is administered by the U.S. Forest Service, is located approximately 45 miles northeast of the Refuge. The Refuge staff work closely with these land management agencies as well as the Many Point Boy Scout Camp, a private entity, and other private citizens on issues of mutual concern.

Social and Economic Context

Tamarac NWR is located in Becker County, Minnesota. The City of Detroit Lakes is the largest town, 22 miles south of the Refuge headquarters with 7,348 people listed in the 2000 Census. The racial makeup of the county is 89 percent white, 7

percent Native American, 0.3 percent African American with Asians, Hispanic and other races contributing 3 percent (Table 1 on page 21).

Area Economy

Table 2 on page 22 shows the economy of the region surrounding the Refuge. The area population increased by 11.3 percent from 1995 to 2005, compared with a 10.0 percent increase for the state of Minnesota and a 11.4 percent increase for the U.S. as a whole. Area employment increased by 30.8 percent from 1995 to 2005, with the state of Minnesota showing a 16.0 percent increase and the U.S. a 17.0 percent increase. Area per capita income increased by 23.7 percent over the 1995-2005 period, while the state of Minnesota and the U.S. increased by 17.3 and 13.2 percent respectively.

Climate

The climate at Tamarac NWR is characterized by warm summers and long, cold winters. Temperatures range from minus 50 degrees Fahrenheit to 107 degrees Fahrenheit. Annual average precipitation is 25 inches with an average annual snowfall of 46 inches. Frost can occur in almost any month although June, July and August are usually frost-free. The annual average growing season is 115 days. Most climatic models predict that this area will warm by 4 degrees to 5 degrees Celsius within the next 50 years.

Geology and Glaciation

Formation of the regional terrain is the result of glaciation, specifically and most recently, the retreat of the Wadena lobe of the Wisconsin ice sheet toward the northwest, leaving a complex series of marginal and terminal moraines. The Itasca moraine, which covers most of the Refuge, and associated outwash plains are a direct result of this glaciation. Moraines are formed by the deposition of soil and rock at the edges of a glacier as it moves. Terminal moraines are associated with the tip of a glacier, whereas, marginal moraines are along sides of the glacier. Water from the melting ice formed lakes and rivers, while glacial till that was deposited formed the moraines. Within Tamarac NWR, a "chain of lakes" was formed along these marginal moraines primarily due to the settling and slumping of wet sediments. The outwash plains were created when "meltwater" carried away fine sediment from the retreating glacier. The outwash plains on the Refuge are characterized by numerous depressions such as kettles, shallow pits, and pot-holes, hence known as "pitted" outwash plains.

Initially the Wadena lobe moved southeastward into northern Minnesota from the limestone belt of

Figure 8: Conservation Lands in the Vicinity of Tamarac NWR

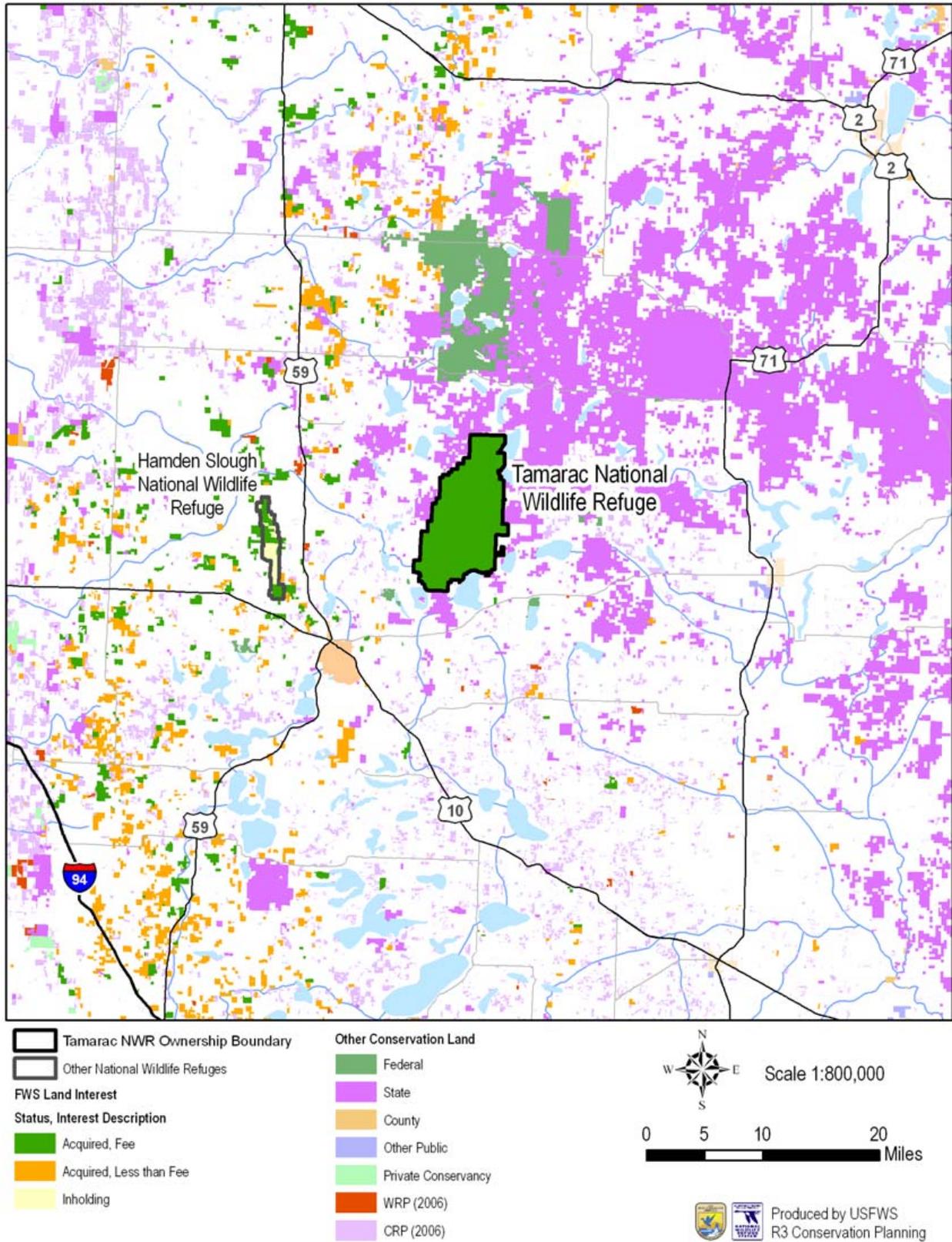


Table 1: Socioeconomic Characteristics of Becker County, Minnesota

Population	Becker County	Minnesota
Population, 2006 estimate	32,230	5,167,101
Population, percent change, April 1, 2000 to July 1, 2006	7.4%	5.0%
Population, 2000	30,000	4,919,479
Persons under 5 years old, percent, 2006	6.4%	6.7%
Persons under 18 years old, percent, 2006	23.2%	24.3%
Persons 65 years old and over, percent, 2006	16.2%	12.1%
Female persons, percent, 2006	50.2%	50.3%
White persons, percent, 2006 (a)	89.6%	89.3%
Black persons, percent, 2006 (a)	0.3%	4.5%
American Indian and Alaska Native persons, percent, 2006 (a)	7.3%	1.2%
Asian persons, percent, 2006 (a)	0.5%	3.5%
Native Hawaiian and Other Pacific Islander, percent, 2006 (a)	0	0.1%
Persons reporting two or more races, percent, 2006	2.2%	1.5%
Persons of Hispanic or Latino origin, percent, 2006 (b)	1.0%	3.8%
White persons not Hispanic, percent, 2006	88.9%	85.9%
Living in same house in 1995 and 2000, pct 5 yrs old & over	61.8%	57.0%
Foreign born persons, percent, 2000	1.0%	5.3%
Language other than English spoken at home, pct age 5+, 2000	4.4%	8.5%
High school graduates, percent of persons age 25+, 2000	82.9%	87.9%
Bachelor's degree or higher, pct of persons age 25+, 2000	16.7%	27.4%
Persons with a disability, age 5+, 2000	4,799	679,236
Mean travel time to work (minutes), workers age 16+, 2000	23.1	21.9
Households, 2000	11,844	1,895,127
Persons per household, 2000	2.49	2.52
Median household income, 2004	\$40,182	\$51,202
Per capita money income, 1999	\$17,085	\$23,198
Persons below poverty, percent, 2004	10.9%	8.1%
Source: U.S. Census Bureau State & County QuickFacts (2008)		

the Winnipeg lowland, depositing calcareous sandy loam and gray till that contains Paleozoic limestone from southern Manitoba. This deposition left behind rich, calcareous fens that are interspersed amongst the marginal moraines. The Wadena lobe retreated northward and re-advanced to form the Itasca Moraine approximately 20,000 years ago. The deposits of sand and gravel drift found throughout the Refuge, supported dense coniferous stands, ultimately resulting in accumulation of organic material in depressions underlain with clay, thus poor drainage is a problem in lower areas.

Soils

A heavy mantle of glacial drift covers all of Becker County. The source material and the mode of deposition of the drift contribute to important differences in soil texture and nutrients that ultimately affect vegetative growth (McAndrews 1966). In general, Refuge soils run on the sandy side, from coarse sand to sandy loams that are well to excessively drained (Table 3 on page 22.). Soils on the northern half of the Refuge are generally lighter than those in the south where all extant grasslands occur. Subsoils are mostly limy clay loams. All areas soil tested to date produced neutral to slightly basic pH readings.

Table 2: Summary of Area Economy, 2005, Tamarac NWR

County	Population		Employment		Per Capita Income ^a	
	2005 ^b	Percent change 1995-2005	2005	Percent change 1995-2005	2005	Percent change 1995-2005
Becker, Minnesota	31.9	10.0%	22.4	44.8%	\$28,968	30.0%
Hubbard, Minnesota	18.8	13.7%	8.0	3.0%	\$26,208	17.5%
Area Total	50.7	11.3%	30.5	30.8%	\$27,588	23.7%
Minnesota	5,126.7	10.0 %	3,498.6	16.0 %	\$37,290	17.3 %
United States	266,278.4	11.4 %	174,249.6	17.0 %	\$34,471	13.2 %

Source: U.S. Department of Commerce 2007.

a. In 2006 dollars.

b. Population and employment in thousands; Per Capita Income in 2006 dollar

Table 3: Distinct Classes of Soils Within Tamarac NWR Based Upon Moisture Capacity and Texture

Soil Moisture Class	Sum Acres	Acre %
01 - Dry Sand	9.2	0.02%
02 - Dry-Mesic Sand	728.8	1.69%
03 - Dry-Mesic Loam	15050.4	35.00%
04 - Mesic Sand	4613.1	10.73%
05 - Mesic Loam	1550.7	3.61%
06 - Wet-Mesic Sand	318.1	0.74%
07 - Wet-Mesic Loam	1444.5	3.36%
09 - Wet Loam	195.1	0.45%
10 - Peat	11200.4	26.05%
11 - Water	7891.9	18.35%
Total	43002.1	100.00%

Soil map units delineated in soil surveys usually do not coincide exactly with habitat, although a strong relationship often exists. The reason for the lack of direct correlation is found in the concepts of soil taxonomy and soil mapping methodology. Soil properties that affect habitat type differentiation are those that affect conditions in plant growth, such as moisture and nutrients. Soil taxonomy, however, is not based directly on such functional properties, but rather on morphological features that can more readily be measure and classified (ie: type of horizon, color, structure and texture. These soil taxonomy parameters may or may not have a direct bearing on plant growth; however, careful examina-

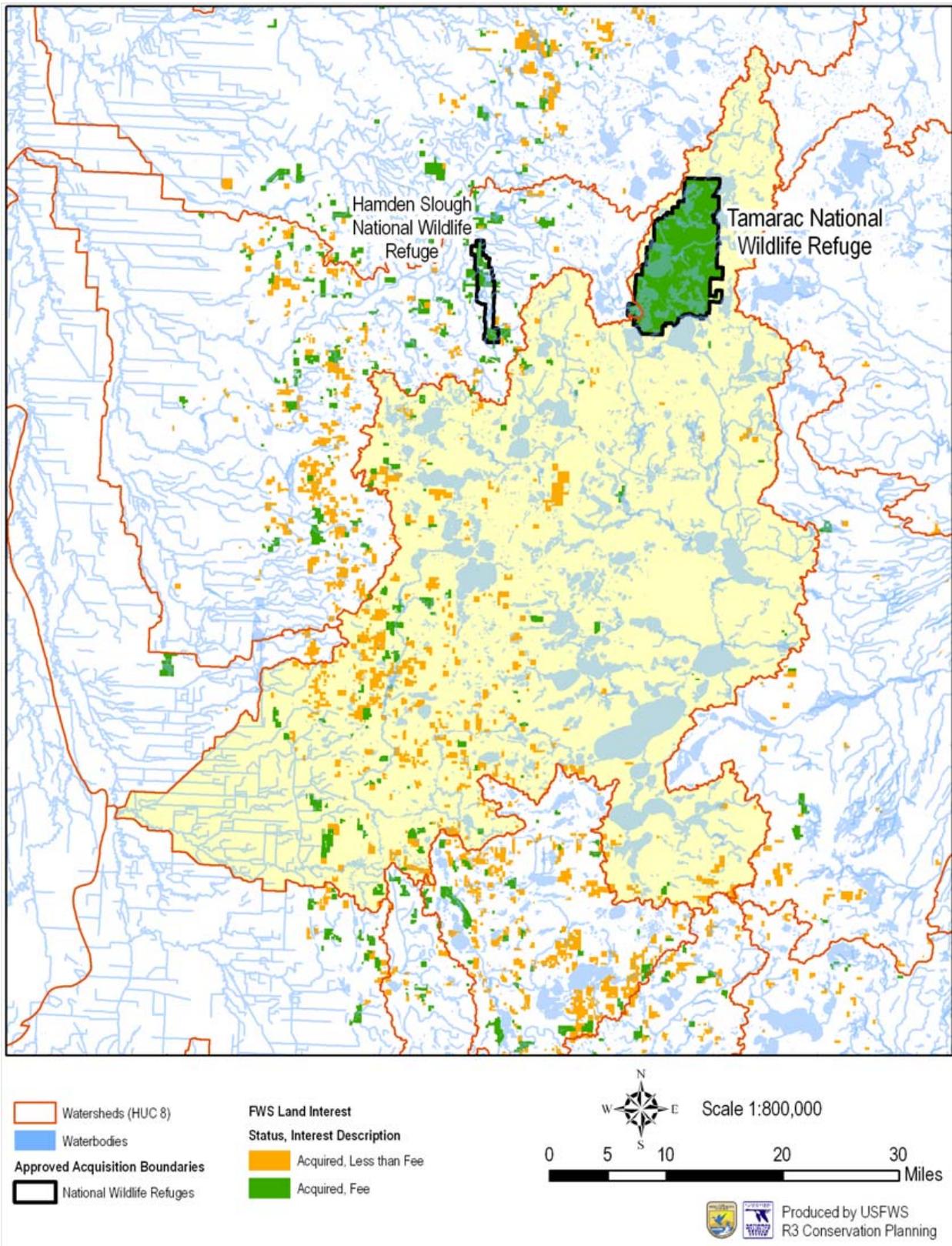
tion of the moisture and nutrient parameters of soils is important in predicting plant growth, successional pathways and subsequent disturbance regimes.

Water and Hydrology

Tamarac NWR is located near or at the top of two major watersheds (Figure 9 on page 23). The Ottertail River watershed originates just north of the Refuge in Elbow Lake. It flows southerly through a chain of lakes along the eastern half of the Refuge, eventually exiting the Refuge via Height of Land Lake in a south-westerly direction. The Egg River, which is a tributary to the Ottertail River, is primarily contained within Refuge boundaries and flows southerly through a chain of lakes along the north-western half of the Refuge and merges into Ottertail River in the central portion of the Refuge. The Buffalo River watershed originates in Pine Lake and exits the Refuge in an east-west fashion via Tamarac Lake along the western boundary of the Refuge. These watersheds eventually drain into Hudson Bay through the Red River of the North. The Continental Divide, which is located a couple of miles just east of Refuge, divides the Red River and Mississippi River Watersheds. There are 31 palustrine wetlands (shallow lakes), 14 miles of riverine habitats and approximately 1,500 small wetlands within the Refuge.

Formation of the regional terrain is the result of glaciation, specifically the retreat of the Wisconsin ice sheet toward the northwest, leaving a complex series of marginal and terminal moraines. The deposits of sand and gravel drift found on the Refuge, supported dense coniferous stands, ultimately resulting in accumulation of organic material in

Figure 9: Location of Tamarac NWR in Relation to Major Watersheds of North-central Minnesota



depressions underlain with clay, thus poor drainage is a problem in lower areas. Elevation ranges from 1,400 to 1,650 feet above mean sea level (MSL). Generally, the higher elevations are in the north-north-east and eastern portions of the Refuge. Broad areas through the central portion of the Refuge are between 1,450 and 1,500 feet above MSL, and the lowest portions are in the extreme southwest corner of the Refuge. Total relief of the Refuge is in excess of 250 feet. The steeper slopes typically exist in the northern one-third of the Refuge, whereas the southern two-thirds is indicative of an outwash plain, containing fewer areas with slopes in excess of 24 percent.

Refuge Habitats

Vegetation on the Refuge is diverse due to its location in the transition zone between northern hardwood and coniferous forests. (See Figure 10 on page 25, and Table 4 on page 27)

Pre-settlement cover types were comprised of mature stands of red and white pine, jack pine barrens, stands of aspen, birch, and mixed hardwoods, numerous lakes, conifer bogs and swamps. The extensive logging of red and white pine virtually eliminated the dominant pine cover types from the landscape. Following the harvest, these timbered lands were burned two to three times in as many years. This practice resulted in appreciable regrowth of aspen, birch, and hardwoods, but not conifers.

Current cover types are significantly altered from pre-settlement times (Figure 11 on page 26). Red and white pine has been reduced by 92 percent and jack pine coverage has been reduced by 89 percent. Significant increases have occurred in mixed hardwood and the aspen-birch cover types (plus 244 and 40 percent, respectively). The upland grass cover type has increased due to remnant openings that were created for farming at the time of settlement.

Forest

Sixty percent of the Refuge is forested, dominated by second-growth timber such as:

- aspen (*Populus* spp.)
- jack pine (*Pinus banksiana*)
- red pine (*Pinus resinosa*)
- white pine (*Pinus strobus*)
- balsam fir (*Abies balsamea*)
- black spruce (*Picea mariana*)
- tamarack (*Larix laricina*)
- paper birch (*Betula papyrifera*)

- red and white oak (*Quercus* spp.)
- sugar maple (*Acer saccharum*)
- American basswood (*Tilia americana*)

For the purpose of this plan, the 50 vegetative cover types were combined into 12 general habitat types (Table 4 on page 27). The vegetative cover types were derived from aerial photo interpretation conducted by the Upper Midwest Environment Sciences Center in LaCrosse, Wisconsin, based on 2005 aerial photography. These 12 major habitat types (Figure 10 on page 25) are described in the following paragraphs.

Upland deciduous forest (16,166 acres): This habitat type includes aspen, paper birch, oak, red and sugar maple, basswood, northern hardwoods and forest broadleaf mix cover types. This habitat type comprises approximately 37 percent of the Refuge land base. Aspen, particularly in the young to mid age classes, dominates this habitat type within the Refuge.

Mixed upland forest (4,347 acres): This habitat type contains a mixture of hardwoods and softwoods, and includes an aspen/birch/spruce/fir mix, aspen/pine and forest upland broadleaf/coniferous mix cover types. This habitat type comprises approximately 10 percent of the Refuge land base. Red and white pines are prevalent in the overstory along with a mix of hardwood, such as aspen and birch. Jack pines are often mixed with pin oak and burr oak on drier sandy soils.

Lowland deciduous forest (756 acres): This habitat type primarily consists of black ash and lowland forest broadleaf mix cover types. These communities are often referred to as black ash swamps. Species composition includes green ash, black ash, and occasionally American elm. The lowland hardwoods are located mostly on medium quality sites which are found along sluggish streams, swamp edges and in depressions within the upland hardwoods.

Mixed lowland forest (463 acres): This habitat type consists of a mix of lowland conifers and hardwoods, primarily black ash, and includes the lowland forested broadleaf/coniferous mix. The mixed lowland forested broadleaf/coniferous is heavily dominated by hardwoods in the overstory.

Upland coniferous forest (711 acres): This habitat type consists of jack pine, red pine, white pine, red cedar (non-native), white spruce/balsam fir and forested coniferous mix as the dominant cover types. As species that once dominated the landscape as pure stands, red pine and white pine comprises only 1 percent (482 acres) of the Refuge, including plantations. Jack pine barrens, which were quite prevalent prior to European settlement, only make

Figure 10: Current Land Cover, Tamarac NWR

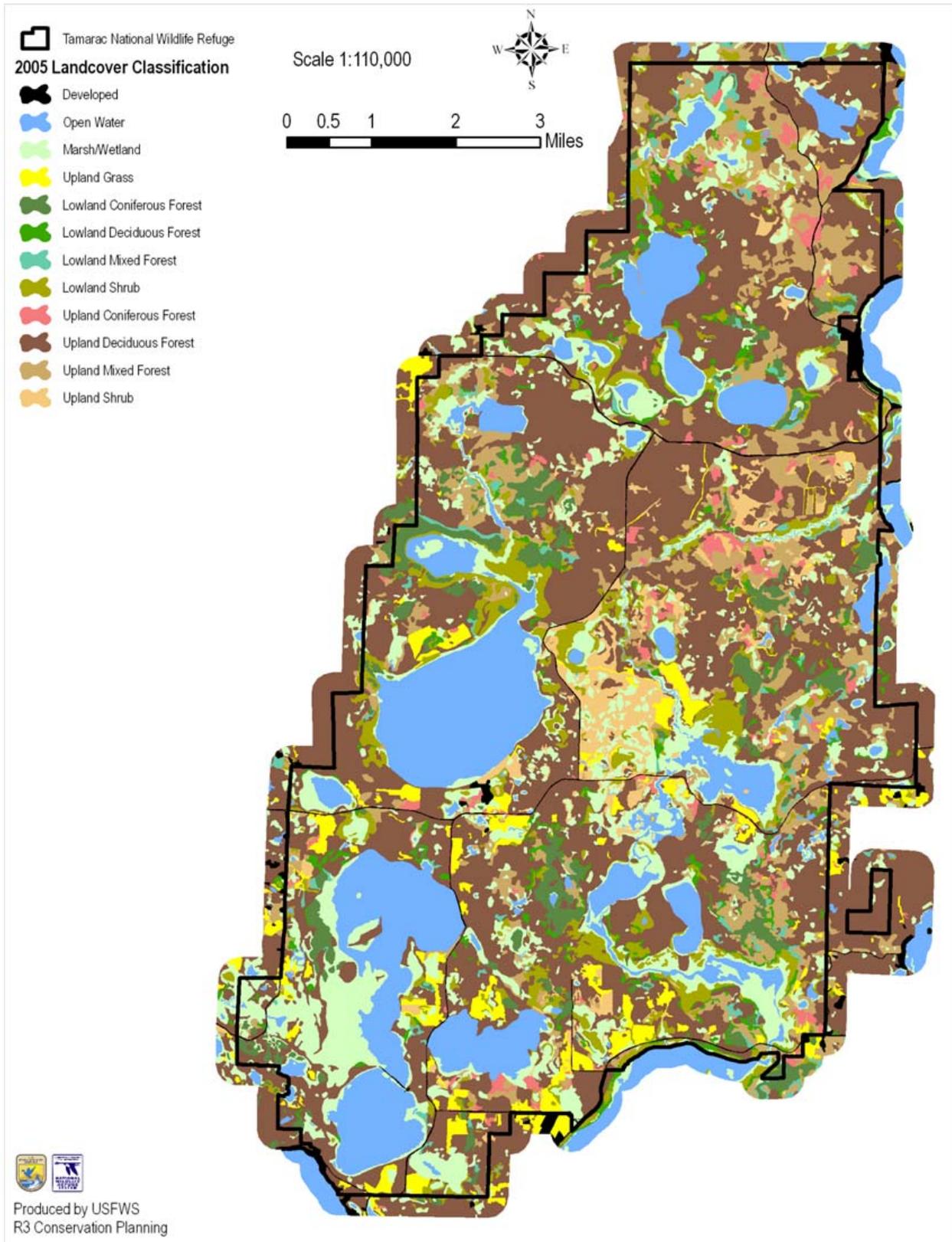
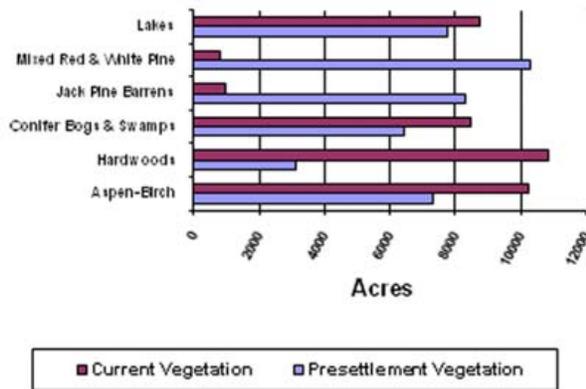


Figure 11: Tamarac NWR Habitat

up about one-quarter of a percent of the Refuge. Jack pine is located in pure stands on dry sandy soils. In heavier soils it is mixed with oak red pine and aspen.

Lowland coniferous forest (1,863 acres): This habitat type consists of pure stands of tamarack, mixed black spruce/balsam fir and lowland coniferous mixed stands. The lowland forested coniferous mix is dominated by lowland conifers such as tamarack, black spruce and balsam fir.

Wetlands

Thirty percent of the Refuge is comprised of large and small wetland complexes dominated by wild rice, sedges and cattail.

Marsh/Wetland (6,248 acres): This habitat type consists of cattail, giant reed grass (*Phragmites*), mixed emergent aquatics, rooted-floating vegetation, sedge meadow/bluejoint grass, sedge meadow/cattail mix, reed canary grass and wet meadow cover types. This is the third most abundant habitat type and comprises approximately 14 percent of the Refuge land base.

Open Water

Open Water (7,116 acres): This habitat type consists of open water, submergent vegetation and wild rice cover types. Although open water is not a plant community, it is classified as such because throughout a majority of the year, the surface consists of open water but vegetation can occur within these areas. Most of these open water habitat types are natural, but some have been enhanced through the construction of water control structures and dikes. Wild rice is an important staple food for waterfowl migrating through the Refuge in the fall, as well as subsistence for Native Americans. This habitat type is the second most abundant habitat type and comprises approximately 16 percent of the Refuge land base.

Grassland

About 1,360 acres (3 percent) of grassland are managed on the Refuge, mostly remnants of early settler clearings or small farms. The tallgrass prairie (Prairie Pothole region in the Red River Valley) begins about 10 miles west of Tamarac NWR.

Upland grass (1,362 acres): This habitat type consists of cool season grasses, other grasses and forbs, and warm season grasses. All of these sites were anthropogenic habitats created as a result of logging and early settler clearings that were planted into agriculture crops in the early days of the Refuge. In recent years, most of these sites have been converted primarily to warm season grasses. Many non-native species of grass and other herbaceous plants are quite prevalent throughout many of these areas.

Shrub

Upland shrub (1,519 acres): This habitat type is dominated by upland shrub species such as hazel, willow, dogwoods and other upland shrubs. Typically few to no trees are present in the overstory and very little herbaceous cover exists where the shrub layer is dense.

Lowland shrub (2,658 acres): This habitat type consists of lowland areas typically within a wetland where the dominant vegetation is shrubs. These areas include bog birch, tag alder, willow and scrub/shrub lowland types. Generally, there is a thick herbaceous cover beneath the shrubs consisting of a variety of sedge species. Large expanses of these areas typically surround the shallow lakes within the Refuge as well as closed wetland systems. A lack of fire within these habitats has resulted in brush species invading and becoming dominant in these areas.

Developed Land

Development (374 acres): This classification is not a true habitat type but merely depicts areas on the Refuge that have been developed such as buildings, maintenance facilities and roads.

Refuge Wildlife

Birds

Tamarac NWR is especially important for migratory birds, both during the migrating and nesting seasons. Fifty-three species of birds that are on the Fish and Wildlife Service's Region 3 Regional Conservation Priority Species list reside on the Refuge or migrate through, although only 21 of these species breed within the Refuge. The remaining 32 species have been documented in migration. Many of these species, as well as other species, are listed

Table 4: Vegetative Cover Types of Tamarac NWR Based on 2005 Aerial Photography Interpretation

Number of stands	Total Acres	Major Habitat Type	Habitat Type	Number of stands	Total Acres
1559	16166	Upland Deciduous	Aspen (Upland)	786	6698
			Aspen/Oak	179	1785
			Basswood	5	9
			Forested Broadleaf Mix (Upland)	299	2346
			Northern Hardwoods	199	4264
			Oak	84	1035
			Paper Birch	1	1
			Red Maple/Sugar Maple	6	29
593	4347	Mixed Upland Forest	Aspen/Birch/Fir/Spruce	240	1579
			Aspen/Pine	190	1601
			Forested Broadleaf/Coniferous Mix (Upland)	163	1168
222	756	Lowland Deciduous	Black Ash	95	313
			Forested Broadleaf Mix (Lowland)	127	442
110	463	Mixed Lowland Forest	Forested Broadleaf/Coniferous Mix (Lowland)	110	463
171	711	Upland Conifer	Jack Pine	19	94
			Jack Pine Plantation	2	9
			Red Pine	33	221
			Red Pine Plantation	27	161
			Red Pine/White Pine	10	34
			White Pine	26	66
			Spruce/Fir	43	95
			Forested Coniferous Mix (Upland)	9	33
270	1863	Lowland Conifer	Spruce/Fir Swamp	7	116
			Tamarack	233	1625
			Forested Coniferous Mix (Lowland)	30	122
279	1519	Upland Shrub	Scrub/Shrub (Upland)	279	1519
536	2658	Lowland Shrub	Bog Birch	10	273
			Scrub/Shrub (Lowland)	442	2020
			Tag Alder	38	98
			Willow	46	266
180	1362	Upland Grass	Cool Season Grasses	71	604
			Grasses/Forbs	83	344
			Hayfields ^a	6	1
			Pasture ^a	4	6
			Warm Season Grasses	16	407

Table 4: Vegetative Cover Types of Tamarac NWR Based on 2005 Aerial Photography Interpretation

Number of stands	Total Acres	Major Habitat Type	Habitat Type	Number of stands	Total Acres
1104	6248	Marsh/Wetland	Cattail	119	897
			Giant Reed Grass (Phragmites)	47	108
			Mixed Emergents	6	26
			Rooted-Floating Vegetation	63	873
			Sedge Meadow/Bluejoint Grass	589	2885
			Sedge Meadow/Typha Mix	278	1457
			Reed Canary Grass	1	2
			Wet Meadow	1	3
243	7116	Open water	Water	86	3464
			Submergent Vegetation	110	2902
			Wild Rice	47	751
19	374	Development	Developed	16	46
			Roadside	3	328

a. Hayfields and pasture in this table were mis-identified in the aerial photo interpretation and are actually cool season grasses.

species of greatest conservation concern by the Minnesota DNR. Of the 258 species of birds that have been observed on the Refuge, 113 species are reported to have nested here. A list of bird species known to occur on Tamarac NWR is included in Appendix C.

Waterfowl have been an important bird group throughout the history of the Refuge. Primary nesters include:

- Mallard Duck
- Wood Duck
- Blue-winged Teal
- Ring-necked Duck
- Canada Goose
- Trumpeter Swan

Duck nesting densities are among the highest reported for the woodland transition zone in Minnesota. Spring surveys indicate slightly more than 40 breeding pairs of ducks per square mile. In addition to the breeding population, approximately 50,000 ducks also migrate through the Refuge each fall stopping to feed on the abundant annual wild rice crops. The Refuge was the focal point for the 1987 Minnesota DNR Trumpeter Swan reintroduction program. The Trumpeter Swan was extirpated from Minnesota in the early 1900s. The population within the Refuge has grown to more than 30 breeding pairs and an annual production of around 100 cygnets per year. Average brood size is nearly twice the national average.

The Refuge is currently cooperating on a Minnesota DNR research study to relate the distribution and welfare of a local population of ducks, specifically Ring-necked Ducks, to the pattern of Refuges (including state refuges) existing in north-central Minnesota. Understanding the factors influencing the distribution of locally raised Ring-necked Ducks in the fall may provide valuable insights into the distribution of refuges required to meet management objectives for Ring-necked Ducks in Minnesota.

As recently as the early 1970s, the Bald Eagle population was in jeopardy throughout the United States. Only one Bald Eagle nest was active on the Refuge. Since that time the number of eagle nests has increased to approximately 30 occupied territories and 25 active nests on an annual basis, producing 20-30 eaglets per year. Other raptors, such as Red-tailed Hawks, Red-shouldered Hawks, Broad-winged Hawks, Cooper's hawks, and Sharp-shinned Hawks breed and migrate through the Refuge.

The wetland ecosystems are particularly important to other waterbirds. These wetlands are ideal nesting sites for species including:

- Common Loons
- Great Blue Heron
- Forster's Tern
- Black Tern
- American Bittern
- Least Bittern
- Yellow Rail
- Sora Rail



Golden-winged Warbler. Photo Credit: FWS

- Virginia Rail
- Sedge Wren
- Swamp Sparrow

Annual surveys of Common Loons indicate nearly 70 adults, but production is less than 10 loon chicks per year.

The diverse forests of Tamarac NWR are well suited for providing habitat for migrating and nesting passerines. Red-eyed Vireos, Ovenbirds, Veery's, Scarlet Tanagers, Rose-breasted Grosbeaks, Golden-winged Warblers and Chestnut-sided Warblers are common breeders throughout the Refuge.

The Refuge has been actively engaged in the Golden-winged Warbler research because of the high nesting densities found on the Refuge due to an abundance of early successional forest habitat within the Refuge's boundaries. The Golden-winged Warbler is currently listed as a Resource Conservation Priority species for Region 3 (USFWS) and is considered a neotropical migratory species of high continental conservation concern by Partners in Flight (PIF) (Rich et al. 2004). Since 1966, the Golden-winged Warbler has declined by approximately 3.5 percent per year across its breeding range. An estimated 76 percent of the global population of Golden-winged Warblers breeds within Bird Conservation Region 12 (BCR12), and approximately 40 percent the global population breed in Minnesota (Rosenberg 2004). Surveys indicate approximately 1 percent to 2 percent of this global population reside within the boundaries of Tamarac NWR.

Although not abundant on the Refuge, various species of shorebirds can be seen throughout the Refuge. The Refuge contains very little mud flat habitats or shallow water (<10 cm) that most shore-

birds prefer. Despite low shorebird densities, the American Woodcock breeds in significant numbers throughout the Refuge, again primarily due to the abundance of young forest habitats. The American Woodcock is also a Resource Conservation Priority species for the Midwest Region due to long-term declines in breeding populations. In Minnesota, there is more early successional forest than there ever were historically, yet the declines persist. The Refuge is currently engaged in research that is examining low productivity rates or "recruitment" as a possible cause for these declines.

Resident bird or year-round species include:

- Ruffed Grouse
- Wild Turkey
- Great-horned Owl
- Barred Owl
- Downy Woodpecker
- Hairy Woodpecker
- Pileated Woodpecker
- Blue Jay
- Black-capped Chickadee
- White-breasted Nuthatch.

Mammals

The Refuge supports 53 species of resident mammals and seven species of bats that migrate off-Refuge to overwinter. Some of the mammal species found on the Refuge are listed as RCPs for Region 3 (ie: gray wolf) and numerous other species are listed species of greatest conservation concern by the Minnesota DNR (ie: Franklin's ground squirrel). Two packs of gray wolves have successfully produced young on the Refuge, and a third pack's territory overlaps into Tamarac NWR. White-tailed deer, beaver, striped skunk, raccoon, muskrat, mink and red squirrels are abundant. White-tailed deer and beaver can severely impact the Refuge's ability to restore or manage habitats. Currently there is an overabundance of white-tailed deer state-wide. The Refuge has recently supported a relatively high density of deer (26 to 28 deer/mi² pre-fawn survey) and thus the adverse effects of browsing in forest understory are significant with huge ecological ramifications. Beaver can have significant effects on water levels which can directly impact the production of wild rice within lakes. Cottontail rabbits and snowshoe hare populations follow a cyclical pattern. Other furbearers, including red fox, coyote, bobcat, fisher, otter, long and short-tailed weasels, are locally common and seen in the area on a regular basis. Based on state-wide surveys conducted by the Minnesota DNR, most of the mammals that are considered "predatory" are well above long-term

trends and historical records (ie: fox, skunk and raccoon), which have devastating effects on ground nesting birds. A list of species known to occur within the Refuge is included in Appendix C.

Fish

Fish surveys have been conducted on select lakes and streams by the Minnesota DNR, the LaCrosse Fishery Resource Office (USFWS), the White Earth Natural Resources Department and various universities in cooperation with the Refuge staff on a periodic basis. Sampling by various methods has documented 37 species of fish including:

- Walleye
- Yellow perch
- Black crappie
- Large-mouth bass
- Bluegill
- Pumpkinseed
- Rock bass
- Brown bullhead
- Yellow bullhead
- Black bullhead
- White sucker
- Northern pike
- Bowfin.

Numerous other fish species were also documented including shiners, dace, chubs, darters and other minnow species (Appendix C). Walleye and lake sturgeon are both listed as Regional Conservation Priority Species (USFWS) for Region 3; however, only the lake sturgeon is listed as a state listed species of special concern.

The Minnesota DNR currently stocks Wauboose and North Tamarac lakes with walleye fry on an every-other year cycle. Likewise, the White Earth Natural Resources Department stocks walleye fry in Lost and Teacacker lakes on a similar cycle. The White Earth Natural Resources Department in cooperation with LaCrosse FRO recently stocked lake sturgeon in Round Lake, which is immediately upstream of the Refuge on the Ottertail River. Although no lake sturgeon were stocked directly in the waters of Tamarac NWR, they have the potential to enter the Refuge via the Ottertail River.

Some of the issues that threaten the Refuge's fishery and waterfowl are undesirable nuisance fish species (bullheads, common carp and fathead minnows), poor survival of naturally produced walleye, and winterkills. All the Refuge water areas, with the exception of Lost and Wauboose Lakes have an

average depth of 8 feet or less and are thus subject to frequent winterkills.

Carp are present within Ottertail River system, but so far restricted in distribution by a box culvert structure in the Hubbel Pond WMA, which is just south of the Refuge. The possibility exists that carp can bypass the box culvert via a ditch from Cotton Lake to Height of Land Lake, thus potentially entering the Refuge as far up the Ottertail River as the Chippewa Lake water control structure and could potentially destroy wetland habitats in Rice and Blackbird lakes. Other fish species, like fathead minnows and walleye, forage on amphipods, which are the primary food resource of migrant and breeding waterfowl. Fathead minnows may be present in lakes that were previously fishless systems.

Reptiles and Amphibians

Eleven species of amphibians and five species of reptiles have been recorded. Lakes, streams, ditches and other wetland basins provide aquatic habitat required for a variety of turtles, frogs, toads and salamanders. Spring peeper, American toad, wood, chorus, northern leopard, gray tree, Cope's gray tree and mink frogs are common. Garter snakes and prairie skinks are common throughout the Refuge. Snapping and painted turtles are also common. The snapping turtle is listed a species of special concern by the Minnesota DNR.

Reptiles and amphibians are important food sources for many mammals, birds and fish. Their numbers and diversity are often indicators of the health of an ecosystem. Many species of reptiles and amphibians are declining on a state and nationwide scale.

Invertebrates

Twenty-five species of butterflies have been documented to date although formalized surveys have not occurred. Refuge wetlands are presumed to contain typical freshwater invertebrates found in the



A woodchuck takes a rest. Photo Credit: Dick Henry



Gray tree frog. Photo Credit: Dick Henry

area but only limited sampling has been done as well. There is speculation that some freshwater invertebrate species have been negatively impacted by fish species that were not historically present within several wetland basins (ie: fathead minnows). Freshwater invertebrates are an extremely important food source for waterfowl, during spring migration, egg laying and brood rearing.

Threatened and Endangered Species

As of July 2010, the gray wolf (*canis lupus*) is the only federally listed endangered species in Becker County. The status of a proposed delisting of the wolf is subject to court action. There are no other federally listed endangered, threatened, proposed or candidate species in Becker County. However, the Canada lynx is listed as threatened in 14 Minnesota counties, including adjacent Clearwater County. Two unverified Canada lynx sightings have been reported in northeastern Becker County.

The state of Minnesota lists 22 endangered, threatened or special concern species, which have been sighted or reproduce on the Refuge. The six species with confirmed reproduction are:

- Gray wolf
- Trumpeter Swan
- Red-shouldered Hawk
- Bald Eagle
- Forster's Tern
- Snapping turtle

The Henslow's Sparrow is state-listed as endangered. The Peregrine Falcon, Wilson's Phalarope, Loggerhead Shrike, Horned Grebe and Common Tern are state-listed as threatened. Although some of the state-listed threatened or endangered species can be occasionally seen during migration, none of

them have been known to breed on the Refuge. Several state-listed species of concern occur on the Refuge, including:

- Short-eared Owl
- Yellow Rail
- Cerulean Warbler
- Franklin's Gull
- American White Pelican
- Northern myotis
- Eastern pipistrelle
- Mountain lion
- Prairie vole
- Woodland vole

Refuge Resources of Concern

Resources of Concern were identified by literature review and expert opinion. Refuge resources of concern include special areas, habitats, ecosystems, and individual species. The National Wildlife Refuge System's Habitat Management Plan policy defines resources of concern as:

“...all plant and/or animal species, species groups, or communities specifically identified in the Refuge purpose, NWRS mission, or international, national, regional, state, or ecosystem conservation plans or acts. Habitats or plant communities should be considered resources of concern when they are specifically identified in the Refuge purpose(s), support species or species groups identified in Refuge purposes, support Service trust species, and/or are important in the maintenance or restoration of biological integrity, diversity and environmental health.”

To better focus on Refuge habitat management, the staff developed a list of Refuge Resources of Concern for Tamarac NWR (Appendix D). Some of these “priority” resources of concern could ultimately be known as “focal” species, which should be representatives of other species or guilds that are highly associated with the same habitat attributes or conditions. These species are not always species imperil or rare, but could be good indicators of a particular habitat type.

Threats to Resources

Invasive Species

Exotic and invasive plant species pose one of the greatest threats to the maintenance and restoration of the diverse habitats found on the Refuge. They threaten biological diversity by causing population declines of native species and by altering key ecosystem processes like hydrology, nitrogen fixation,



Bio-agents are released to control leafy spurge. Photo Credit: FWS

and fire regimes. Left unchecked, these plants can come to dominate areas and reduce the value of the land as wildlife habitat. There is often a seed source of many of these exotic/invasive species on the lands surrounding the Refuge, thus in order to be effective with our efforts, we must bring together a complex set of interests including private landowner, commercial, and public agencies to combat invasive species and restore native plants.

Three categories of undesirable species (invasive, exotic, noxious) are found within the Refuge. Invasive species are alien species whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Executive Order 13112 – Invasive Species, dated February 3, 1999, directs federal agencies to use relevant programs and authorities to prevent the introduction of invasive species, detect and respond rapidly to and control populations of such species, monitor invasive species infestations accurately and reliably, and promote public education on these species and methods to address them. Exotic species are those that are not native to a particular ecosystem. Service policy also directs the Refuge to try to maintain habitats free of exotic species. Noxious weeds are designated by the U.S. Department of Agriculture or the Minnesota Department of Agriculture as species which, when established, are destructive, competitive or difficult to control.

Baseline information on invasive species presence, distribution, density, etc. is crucial for setting

priorities for control, developing management strategies, estimating impacts and evaluating management effectiveness. A long-term invasive weed mapping/monitoring program using GPS technology was initiated in 2005. On Tamarac NWR, there are currently numerous invasive species of concern and the Refuge uses an integrated approach to control these weeds. Control methods have included cultural (tillage, burning, cropping, mowing, haying, etc.), chemical and biological (bio-agents) methods. Canada thistle, plumeless thistle, purple loosestrife, leafy spurge and spotted knapweed are introduced species that occur on the Refuge that are classified as prohibited noxious weeds in Minnesota. Other invasive species known to occur on the Refuge include:

- hybrid cattail
- hoary alyssum
- Siberian peashrub
- Kentucky bluegrass
- yellow starthistle
- birdsfoot trefoil
- reed canarygrass
- perennial sowthistle
- common tansy
- quackgrass
- smooth brome

Although flowering rush is not known to occur on the Refuge, it is an imminent threat to the Refuge aquatic resources as it is fairly abundant in the lakes around the Detroit Lakes area. Eurasian milfoil is not common in the area but is a species of concern and poses a threat in the local area. The species is being monitored by the local Minnesota DNR. Detroit Lake typically sees significant boat traffic, and many of these boats use other lakes in the greater Detroit Lakes area, including Tamarac NWR, increasing the spread potential to the Refuge.

Canada and plumeless thistle are controlled through chemical and mechanical means, as well as through competition from native seeded warm season grasses including big and little bluestem, Indiangrass, switchgrass, etc. Purple loosestrife is controlled by hand pulling isolated plants prior to seed production or by chemical application on larger infestations. Leafy spurge and spotted knapweed are controlled primarily through the use of biological control agents. A few other invasive species are known to occur on the Refuge and the appropriate control strategy is applied accordingly; however the species listed above take priority due to proliferation and their threat to native plant communities.

Earthworms

In the Great Lakes region, native earthworm species have never been documented, and any native species of earthworms living in the region were extirpated when glacial ice sheets covered the Upper Midwest 11,000 to 14,000 years ago (NRRI 2007). Therefore, forests of the Great Lakes Region developed in the complete absence of earthworms. For thousands of years, no earthworms existed in this region until European settlers began arriving around the mid 1800s.

Researchers have documented dramatic changes in native hardwood forest ecosystems when exotic earthworms invade, including loss of native understory plant species and tree seedlings, changes in soil structure and declines in nutrient availability (Hale 2004). Exotic earthworms not only alter ecosystem components, but they also change some of the important underlying processes, such as fire, succession, and natural regeneration, that support the health and diversity of forest plants and animals. In addition, research suggests the changes caused by exotic earthworms may lead to a cascade of other changes in the forest that affect small mammal, bird and amphibian populations. Earthworm presence may also increase the impacts of herbivores like white-tailed deer and facilitate invasions of other exotic species, making them a potential threat to the biodiversity and long-term stability of forest ecosystems in the region. Recent research suggests earthworm can potentially affect water quality by mobilizing phosphorus levels.

The Refuge has a significant infestation of earthworms. At this time, there is no known technique for managing or eradicating these non-native earthworms. The Refuge intends to assess the earthworm distribution on the Refuge in the near future using protocol developed by researchers at the Natural Resources Research Institute in Duluth, Minnesota. Refuge staff will need to be cognizant of the potential impacts of earthworms to management success and desired future habitat conditions during all future forest planning and management on the Refuge.

White-tailed Deer

The Refuge is officially designated as a white-tailed deer management unit (251), but the Minnesota DNR and Tamarac NWR cooperatively manage the deer herd and administer harvest regulations within the Refuge. Recently, there has been an overabundance of white-tailed deer statewide. Relatively high densities of deer (26 to 28 deer/mi² pre-fawn survey) have occurred on the Refuge within the last decade. Over-browsing by deer could lead to significant ecological ramifica-

tions, particularly when coupled with earthworm infestation problems. Long-term over-browsing by deer reduces plant cover and diversity, alters nutrient and carbon cycling, and redirects succession to shift future overstory composition (Dussault and Waller 2004). The impacts of deer over-browse on plants can also cascade to affect species diversity, from insects to amphibians to migratory songbirds. Impacts on vegetative structure and abundance have been noted with deer exclosures on the Refuge.

Zebra Mussel

The zebra mussel, a non-native mussel from Russia, has been rapidly spreading across the Midwest. Zebra mussels pose serious ecological and economic threats to the aquatic resources of Minnesota. Heavy infestations can kill native mussels, impact fish populations, interfere with recreation, increase costs for industry, and alter aquatic ecosystems.

In September 2009, both adult and young zebra mussels were discovered in Pelican Lake, Ottertail County which is approximately 20 (straight-line) miles from the Refuge. This is the first discovery of zebra mussel within the Red River and Ottertail River watershed. Although the Refuge is a distance upstream from Pelican Lake, the approximation of Tamarac NWR to this new infestation has heightened the threat of zebra mussel invasion to the Refuge substantially. Pelican Lake typically sees significant boat traffic, many of which utilize other



Spotted knapweed. Photo Credit: FWS

lakes in the greater Detroit Lakes area, including Tamarac NWR, thus increasing the threat potential to the Refuge.

Other Forest Pests and Pathogens

Refuge staff continually monitor the health and condition of the forests on the Refuge and stay abreast of the regional status of insects and disease that affect the forests. The goal of the Refuge is to protect the health of our forests by preventing, where possible, the introduction of forest insects and diseases in the area.

Native epidemic pests have exhibited outbreak behavior throughout recorded history and although unpredictable, their outbreaks are expected to occur. However, human influence has subjected forests to exotic insect species that are prone to spectacular outbreaks. Disturbances such as climate change, fire suppression and even-aged forest management can increase the severity, frequency and distribution of exotic and native insects.

Forest tent caterpillars, gypsy moth, jack pine bud worms, Asian long-horned beetle, and emerald ash borers (EAB), oak wilt, white pine blister rust, Dutch elm disease, are just a few of the insects and diseases of concern to the Refuge. Currently, the emerald ash borer is the most serious forest pest concern in eastern U. S. It attacks and kills all ash trees. In 2009, EAB was discovered in Minnesota in the Twin Cities area. The spread to remainder of the state is imminent. Early detection of invasive insects and disease is key to effective control of these unwanted forest pests and pathogens.

Contaminants

Tamarac NWR is not near any major point-sources of pollution, and the Refuge has limited risk from spills. Instead, the Refuge is more likely to be impacted from air pollution that may originate from other sources well beyond the Refuge boundaries.

Mercury is a pervasive contaminant across Minnesota, necessitating a statewide Fish Consumption Advisory from the Minnesota Department of Health. Air pollution is the major source of mercury contamination to Minnesota's lakes and rivers. About 70 percent of the mercury in the air is the result of emissions from coal combustion, mining, and the incineration of mercury-containing products, the remaining 30 percent is derived from natural emissions. Only about 10 percent of Minnesota's mercury contamination originates from Minnesota emissions, however, 90 percent of Minnesota's emissions are deposited in other states and countries (Minnesota Pollution Control Agency, 2005).

Several lakes within the surrounding area of the Refuge are listed on the Minnesota Impaired Water list due to mercury as the pollutant. These lakes include Cotton, Island, Many Point, Toad, Floyd, Detroit and White Earth. The increasing presence of mercury within inland lakes has prompted the Minnesota Department of Health to issue a Fish Consumption Advisory. The advisory provides guidelines regarding the size and frequency of which fish species can be eaten safely. No formal testing of fish or wildlife for the presence of contaminants has been conducted on the Refuge.

In 2005, the Refuge initiated an environmental site assessment at the former Job Corps Conservation Center (JCCC). The goal of this project was to identify and remove any existing environmental contaminants that were still present within the JCCC area. The JCCC was a complex, administered by the U.S. Army Corps of Engineers, that was constructed in 1965 to house, educate and train youth. The area encompassed approximately 180 acres just north of Height of Land Lake. Although the JCCC program was terminated on the Refuge in 1969, the facilities were used by a Native American group until 1980, when the site was abandoned and the buildings were reclaimed, sold or demolished. Asphalt driveways, concrete foundations, telephone pedestals, buried pipes, underground storage tanks sewage lagoon (presently dry) and an inactive solid waste dump remained on the site.

Three underground storage tanks (fuel tanks) were removed in 2005 and the soil around them was tested. All soil tests were negative for benzene, ethyl-benzene, toluene, xylene, gasoline range organics and diesel range organics. Two water wells were also sealed with bentonite for contaminant prevention to the groundwater. In 2008, five injection wells (septic tanks) were inspected and closed by filling them with clean dirt. Concrete pads, industrial hoists and metal pipes were also removed from the site. In 2009, a site assessment by Tetra Tech. was conducted and concluded that the landfill needed to be tested to determine remediation action. Additional soil testing for lead and asbestos around the building demonstration sites was also recommended and one additional septic tank was identified for closure. The work is scheduled for 2010.

Climate Change and Tamarac NWR

Various forest ecologists with expertise in disturbance regimes and potential climate change impacts have suggested that this area will likely see significant ecological changes in the forest landscape and associated habitats for wildlife. One ecologist goes so far as to state "the only forest that may be left in

Minnesota after climate change runs its course, would be located in the Boundary Waters along the Canadian border in extreme northeastern Minnesota.” Ironically, a study conducted by University of Minnesota Professor John Tester about 15 years ago documented that just a subtle change in abiotic factors, such as temperature and precipitation, impacted these major biomes. The study represented a gradient of ecotones within a 50-mile east-west transect that transitioned from boreal forest to deciduous forest to brushlands to tallgrass prairie. The difference in temperature between the boreal forest and tallgrass prairie was a mere 4 degrees Celsius. Significant differences were documented in plant and animal species.

For example, starting in the boreal forest and ending in the tallgrass prairie, four different grouse species with specific habitat needs were documented (Spruce Grouse, Ruffed Grouse, Sharp-tailed Grouse and Greater Prairie Chicken). The same pattern was noted in small mammals and other species groups. All of the future climate models predict this same area will warm by at least 4 degrees Celsius in the next 50 years. The ultimate question is what’s in store for wildlife and their associated habitats in the future with potential climate changes? How does a land manager plan for future habitat management for wildlife within this tension zone, facing uncertainty with regard to climate change?

In addition, the Refuge was established in the mid-1930s as a result of the reinvigorated national waterfowl restoration program by the U. S. Fish & Wildlife Service to restore the nesting grounds of the waterfowl resource. This was during the Dust Bowl Era when the prairie potholes of the Dakotas were dry, thus significant waterfowl use was present in the shallow lakes of Tamarac NWR and the transition zone of Minnesota. Since that time, precipitation and water levels have returned to prairies, luring waterfowl populations back to the prairie potholes. Dr. Carter Johnson of South Dakota State University suggests the most productive habitat for breeding waterfowl are poised to shift from the prairie potholes to wetter eastern and northern fringes where many wetlands have already been drained (Johnson et al. 2005). How important will the transition zone of Minnesota be under the predicted climate models?

Midwest Climate Change Impacts

The U.S. Department of the Interior issued an order in January 2001 requiring federal agencies under its direction that have land management responsibilities to consider potential climate change impacts as part of long range planning endeavors.

The increase of carbon dioxide within the earth’s atmosphere has been linked to the gradual rise in surface temperature commonly referred to as global warming. In relation to comprehensive conservation planning for national wildlife Refuges, carbon sequestration constitutes the primary climate-related impact that refuges can affect in a small way. The U.S. Department of Energy’s “Carbon Sequestration Research and Development” defines carbon sequestration as “...the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere.”

Vegetated land is a tremendous factor in carbon sequestration. Terrestrial biomes of all sorts – grasslands, forests, wetlands, tundra, and desert – are effective both in preventing carbon emission and acting as a biological “scrubber” of atmospheric carbon dioxide. The Department of Energy report’s conclusions noted that ecosystem protection is important to carbon sequestration and may reduce or prevent loss of carbon currently stored in the terrestrial biosphere.

Conserving natural habitat for wildlife is the heart of any long-range plan for national wildlife refuges and management areas. The actions proposed in this CCP would conserve or restore land and habitat, and would thus retain existing carbon sequestration. This in turn contributes positively to efforts to mitigate human-induced global climate change.

One Service activity in particular – prescribed burning – releases carbon dioxide directly to the atmosphere from the biomass consumed during combustion. However, there is actually no net loss of carbon, since new vegetation quickly germinates and sprouts to replace the burned-up biomass and sequesters or assimilates an approximately equal amount of carbon as was lost to the air (Boutton et al. 2006). Overall, there should be little or no net change in the amount of carbon sequestered at Tamarac NWR from any of the proposed management alternatives.

Several impacts of climate change have been identified that may need to be considered and addressed in the future:

- Habitat available for cold water fish such as trout and salmon in lakes and streams could be reduced.
- Forests may change, with some species shifting their range northward or dying out, and other trees moving in to take their place.
- Ducks and other waterfowl could lose breeding habitat due to stronger and more frequent droughts.



Canadian tiger swallowtail butterfly. Photo Credit: R. Hickner

- Changes in the timing of migration and nesting could put some birds out of sync with the life cycles of their prey species.
- Animal and insect species historically found farther south may colonize new areas to the north as winter climatic conditions moderate.

The managers and resource specialists responsible for the Refuge need to be aware of the possibility of change due to global warming. When feasible, documenting long-term vegetation, species, and hydrologic changes should become a part of research and monitoring programs. Adjustments in land management direction may be necessary over the course of time to adapt to a changing climate.

The following paragraphs are excerpts from the 2000 report: *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*, produced by the National Assessment Synthesis Team, an advisory committee chartered under the Federal Advisory Committee Act to help the US Global Change Research Program fulfill its mandate under the Global Change Research Act of 1990. These excerpts are from the section of the report focused upon the eight-state Midwest Region.

Observed Climate Trends

Over the 20th century, the northern portion of the Midwest, including the upper Great Lakes, has warmed by almost 4 degrees Fahrenheit (2 degrees Celsius), while the southern portion, along the Ohio River valley, has cooled by about 1 degree Fahrenheit (0.5 degrees Celsius). Annual precipitation has increased, with many of the changes quite substantial, including as much as 10 to 20 percent increases over the 20th century. Much of the precipitation has resulted from an increased rise in the number of days with heavy and very heavy precipitation events. There have been moderate to very large

increases in the number of days with excessive moisture in the eastern portion of the Great Lakes basin.

Scenarios of Future Climate

During the 21st century, models project that temperatures will increase throughout the Midwest, and at a greater rate than has been observed in the 20th century. Even over the northern portion of the region, where warming has been the largest, an accelerated warming trend is projected for the 21st century, with temperatures increasing by 5 to 10 degrees Fahrenheit (3 to 6 degrees Celsius). The average minimum temperature is likely to increase as much as 1 to 2 degrees Fahrenheit (0.5 to 1 degree Celsius) more than the maximum temperature. Precipitation is likely to continue its upward trend, at a slightly accelerated rate; 10 to 30 percent increases are projected across much of the region. Despite the increases in precipitation, increases in temperature and other meteorological factors are likely to lead to a substantial increase in evaporation, causing a soil moisture deficit, reduction in lake and river levels, and more drought-like conditions in much of the region. In addition, increases in the proportion of precipitation coming from heavy and extreme precipitation are very likely.

Midwest Key Issues:

1. Reduction in Lake and River Levels

Water levels, supply, quality, and water-based transportation and recreation are all climate-sensitive issues affecting the region. Despite the projected increase in precipitation, increased evaporation due to higher summer air temperatures is likely to lead to reduced levels in the Great Lakes. Of 12 models used to assess this question, 11 suggest significant decreases in lake levels while one suggests a small increase. The total range of the 11 models' projections is less than a 1-foot increase to more than a 5-foot decrease. A 5-foot (1.5-meter) reduction would lead to a 20 to 40 percent reduction in outflow to the St. Lawrence Seaway. Lower lake levels cause reduced hydropower generation downstream, with reductions of up to 15 percent by 2050. An increase in demand for water across the region at the same time as net flows decrease is of particular concern. There is a possibility of increased national and international tension related to increased pressure for water diversions from the Lakes as demands for water increase. For smaller lakes and rivers, reduced flows are likely to cause water quality issues to become more acute. In addition, the projected increase in very heavy precipitation events will

likely lead to increased flash flooding and worsen agricultural and other non-point source pollution as more frequent heavy rains wash pollutants into rivers and lakes. Lower water levels are likely to make water-based transportation more difficult with increases in the costs of navigation of 5 to 40 percent. Some of this increase will likely be offset as reduced ice cover extends the navigation season. Shoreline damage due to high lake levels is likely to decrease 40 to 80 percent due to reduced water levels.

Adaptations: A reduction in lake and river levels would require adaptations such as re-engineering of ship docks and locks for transportation and recreation. If flows decrease while demand increases, international commissions focusing on Great Lakes water issues are likely to become even more important in the future. Improved forecasts and warnings of extreme precipitation events could help reduce some related impacts.

2. Agricultural Shifts

Agriculture is of vital importance to this region, the nation, and the world. It has exhibited a capacity to adapt to moderate differences in growing season climate, and it is likely that agriculture would be able to continue to adapt. With an increase in the length of the growing season, double cropping, the practice of planting a second crop after the first is harvested, is likely to become more prevalent. The CO₂ fertilization effect is likely to enhance plant growth and contribute to generally higher yields. The largest increases are projected to occur in the northern areas of the region, where crop yields are currently temperature limited. However, yields are not likely to increase in all parts of the region. For example, in the southern portions of Indiana and Illinois, corn yields are likely to decline, with 10-20 percent decreases projected in some locations. Consumers are likely to pay lower prices due to generally increased yields, while most producers are likely to suffer reduced profits due to declining prices. Increased use of pesticides and herbicides are very likely to be required and to present new challenges.

Adaptations: Plant breeding programs can use skilled climate predictions to aid in breeding new varieties for the new growing conditions. Farmers can then choose varieties that are better attuned to the expected climate. It is likely that plant breeders will need to use all the tools of plant breeding, including genetic engineering, in adapting to climate change. Changing planting and harvest dates and planting densi-

ties, and using integrated pest management, conservation tillage, and new farm technologies are additional options. There is also the potential for shifting or expanding the area where certain crops are grown if climate conditions become more favorable. Weather conditions during the growing season are the primary factor in year-to-year differences in corn and soybean yields. Droughts and floods result in large yield reductions; severe droughts, like the drought of 1988, cause yield reductions of over 30 percent. Reliable seasonal forecasts are likely to help farmers adjust their practices from year to year to respond to such events.

3. Changes in Semi-natural and Natural Ecosystems

The Upper Midwest has a unique combination of soil and climate that allows for abundant coniferous tree growth. Higher temperatures and increased evaporation will likely reduce boreal forest acreage, and make current forestlands more susceptible to pests and diseases. It is likely that the southern transition zone of the boreal forest will be susceptible to expansion of temperate forests, which in turn will have to compete with other land use pressures. However, warmer weather (coupled with beneficial effects of increased CO₂), are likely to lead to an increase in tree growth rates on marginal forestlands that are currently temperature-limited. Most climate models indicate that higher air temperatures will cause greater evaporation and hence reduced soil moisture, a situation conducive to forest fires. As the 21st century progresses, there will be an increased likelihood of greater environmental stress on both deciduous and coniferous trees, making them susceptible to disease and pest infestation, likely resulting in increased tree mortality.

As water temperatures in lakes increase, major changes in freshwater ecosystems will very likely occur, such as a shift from cold water fish species, such as trout, to warmer water species, such as bass and catfish. Warmer water is also likely to create an environment more susceptible to invasions by non-native species. Runoff of excess nutrients (such as nitrogen and phosphorus from fertilizer) into lakes and rivers is likely to increase due to the increase in heavy precipitation events. This, coupled with warmer lake temperatures, is likely to stimulate the growth of algae, depleting the water of oxygen to the detriment of other living things. Declining lake levels are likely to cause large impacts to the current distribution of wetlands. There is some chance that some wetlands could gradually migrate, but in areas where their migration is

limited by the topography, they would disappear. Changes in bird populations and other native wildlife have already been linked to increasing temperatures and more changes are likely in the future. Wildlife populations are particularly susceptible to climate extremes due to the effects of drought on their food sources.

Administrative Facilities

The primary facility on Tamarac NWR is a combined Visitor Center and Refuge Headquarters located on Highway 26. The Visitor Center portion features an exhibit area, an observation deck, a book shop and an auditorium/theater. The Headquarters portion contains office space for most of the Refuge staff. Workshops, garages, storage buildings, and additional offices are located just east of the Refuge Headquarters.

Visitor Services

Between 60,000 to 85,000 visitors per year visit Tamarac NWR. The number of people that visit per year is dependent upon many factors, some which we control, such as the number of programs offered and outreach efforts.

The Refuge's Visitor Center is open year-round. In the winter and spring, the Visitor Center is open Monday through Friday from 8 a.m. to 4 p.m. In the summer and fall, the hours are extended to 10 a.m. to 5 p.m. on weekends.

Attractions include informational and interpretive displays such as a children's touch table, a Bald Eagle's nest, a 'sounds of the Refuge' display, Trumpeter Swan mounts and more.

The Visitor Center also features a 12-minute orientation to the Refuge theater presentation.

Other facilities include:



Tamarac NWR Visitor Center. Photo Credit: FWS

- Old Indian Hiking Trail on County Road 29 winds through maple-basswood and diverse forest for approximately 1.5 miles.
- All roads and trails in the Visitor Use Area are open for hiking year-round and snowshoeing during winter months. Roads and trails in the Sanctuary Area are open for hiking, snowshoeing or skiing from September through February.
- Blackbird Auto Tour Drive, a 5-mile long, self-guided interpretive trail which travels through forested areas and follows the edge of lakes, marshes and bogs. The tour is open from April 15 through December 15, road conditions permitting.
- Two observation decks, each with spotting scopes and interpretive panels.
- Trails and parking areas available for hunting waterfowl, deer and small game.
- Boat access available at Tamarac, Rice, Lost, Waboose, Blackbird, Height of Land, Cotton, Egg, Two Island, Day, Pine and Carmen Lakes.
- Information kiosks at the Visitor Center, the southern entrance on Highway 29 and the western entrance on Highway 26.
- The Chippewa site, along the banks of the Otter Tail River, offers tables, grills and restrooms.
- The Pine Lake Ski Trail is open seasonally and offers two occasionally groomed loops approximately 2 and 6 miles. A parking lot and trail head map are located on County Road 29.
- Eleven historic monuments.

Current Management

Consistent with its authorizing legislation, Tamarac NWR conducts a broad array of wildlife and habitat management activities while providing for a variety of visitor services. Efforts to balance competing demands for natural resources, wildlife, and protection from environmental hazards are crucial. Refuge management has made significant progress in implementing planned activities over the years since establishment. Refuge planning and management, however, are a continual work in progress and evolve over time, depending on feedback and monitoring as well as changing values, needs, and priorities in wildlife management at the Refuge, regional, and national scale.

Habitat Management

Land management on the Tamarac NWR has shifted over time from the wholesale logging of the



Bald Eagle and eaglet. Photo Credit: D. Braud

late 1800s, to pioneer settlement and agricultural attempts, to the edge management of early wildlife management, and on to the landscape and disturbance ecology of today.

As our knowledge and understanding of landscape ecology and wildlife management evolve over time, and as circumstances and values “on the ground” change, the direction of habitat management tends to change as well. By keeping the “Wildlife First” motto at the forefront of refuge management the Tamarac NWR is adhering to the refuge purpose. Although the Refuge’s original focus was on waterfowl (ducks and geese), other migratory birds, such as forest passerines, and resident wildlife, such as wolves and deer, have received an increasing emphasis in Refuge management over the years. In addition, a more holistic approach has been proposed for the future through ecosystem management principles and philosophies. The Refuge will accomplish these purpose(s) and mission by ensuring that the biological integrity, diversity, and environmental health of the Refuge are maintained and, where appropriate, restored.

The U.S. Fish and Wildlife Service’s biological integrity policy (U. S. Fish and Wildlife Service 2001) directs the agency to “maintain and restore, where appropriate, the biological integrity, diversity and environmental health of the National Wildlife Refuge System (NWRS). Biological diversity can be referred to as the variety of life including its processes; whereas, biological integrity refers to the “biotic composition, structure and functioning at genetic, organism and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms and communities. Environmental health in the policy refers to the composition, structure, and functioning of soil, water, air, and other abiotic features comparable with the historic conditions, including the natural abiotic processes that shape the environment. Unlike many locations in the upper Midwest,

Tamarac NWR has the unique ability to manage for biological integrity based upon the ecosystem approach, without overemphasizing single species management.

From the time of Refuge establishment, until the mid 1960s when acquisition boundaries were complete, much of the Refuge management focused on land acquisition and management of the waterfowl resources. From 1979 to 1992, the Refuge was managed under the guidance of the Tamarac NWR Master Plan. The primary management objective under this plan was the production and maintenance of waterfowl. This often was thought of as the more water that could be placed on the landscape, the more waterfowl that could be produced. Secondary objectives were directed toward maintaining an ecological balance between resident species their habitat and providing public opportunities such as hunting, fishing and wildlife observation.

Currently, Tamarac NWR operates under the guidance of the Refuge Management Plan (1992). This plan put forth the current mission for Tamarac NWR:

“Manage Refuge habitats to maximize biodiversity, with emphasis on endangered species and waterfowl production and maintenance, while providing visitor opportunities, compatible with Refuge purposes, that produce high quality education, interpretation and recreation experiences.”

Management emphasis of this plan focused on furthering the purposes for which Tamarac NWR was established, primarily production and maintenance of migratory waterfowl, with only endangered species having a higher priority than waterfowl.

The goals and the specific objectives stated in the 1992 Refuge Management Plan were pursued by an aggressive habitat management program involving wetland, forest, grassland and fire management and a diverse public use program to provide a wide variety of recreational, interpretive and educational programs. These Refuge habitat goals were essentially divided and managed via three succinct management disciplines through individual step down plans: forest management plan (1994), grassland management plan (1990) and marsh & water management plan (1992), which provided more specificity to habitat management.

Wetland Management

In the early years of Refuge management, the management philosophy focused on constructing water control structures to create more waterfowl habitat. Refuge management philosophies have changed, and today, wetlands are being managed based on historical distribution and hydrological

regimes to the extent possible. The basic purpose of water level management on the Refuge has been to enhance the area's natural ability to grow wild rice and maintain aquatic ecosystems for the benefit of migrating waterfowl and other wetland dependent species.

A total of 30 shallow lakes are managed on the Refuge using one of three management strategies:

- Active water manipulation
- Removal of problem beaver dams as necessary
- No water level manipulation

The 1992 Marsh and Water Management Plan clearly articulated which strategy will be used for each lake and subsequently, lakes with active water manipulation have "target" water levels prescribed for different time periods throughout the year. According to the plan, eleven lakes/pools were to be addressed annually. However, only six lakes have management capability via water control structures and only four of those have been actively manipulated in recent years. With the exception of South Tamarac, which is controlled by a pumping station, all lakes are managed through natural gravity flow and runoff and are considered gravity flow systems.

Throughout Refuge history, water control structures have been used to manipulate water levels to maximize wild rice production. Initially, as each water control structure became functional elevations were established for each lake based on flooding a majority of the pool to a depth of 4 feet or less. Later some of the approved elevations changed based on observations and experiences of Refuge staff. Historically, approved levels were generally held constant throughout the year. From 1959 to the mid 1980s, management tactics focused on moving high spring runoff through Refuge lakes as rapidly

as possible and stabilizing water levels throughout the growing season stabilizing water levels so that the growth of wild rice would benefit waterfowl by providing brood cover and food for migrants.

Since that time, management efforts have attempted to allow these natural fluctuations to occur in order to sustain the long-term viability of wild rice production, particularly in the Rice, Blackbird, Flat and Little Flat Lakes. Wild rice evolved through a cyclic process of water level fluctuations depending upon precipitation, runoff, and evaporation in any given year. For example, in a 10-year period, there were likely a couple drought years, a couple flood years, and some years with water levels in between these extremes. Recent research (Carson 2002) indicates stable water levels over time jeopardize the long-term viability of a wild rice dominated lake by allowing undesirable species to out-compete wild rice.

Under today's strategy, annual water level prescriptions are not rigid, but rather targets that provide the flexibility for wetland enhancement and management of aquatic ecosystems. The primary intent is to allow water to flow through naturally during peak periods such as spring run-off or heavy rain events, rather than restrict the flow. It is recognized that these water control structures do pose a fish barrier problem, but that seems to be an advantage with common carp in the Ottertail River systems just below the dam in Hubbel Pond Wildlife Management Area.

Open Landscape Management

The Refuge currently manages about 2,800 acres (6.5 percent of the Refuge) as upland grass/brush habitat. Most of these areas are remnants of the early settler clearings or small farms which followed the virgin timber harvest or the late 1800s. Early management of grassland "openings" in the landscape was through intensive farming efforts. Food plots were established as part of an aggressive goose restoration program in the 1950s. Once Canada Geese were successfully restored in the area, many of these food plots were slowly converted to dense nesting cover (DNC) for the benefit of nesting waterfowl. In recent years, many of these DNC fields have been converted to stands of warm season grasses and forbs, and most have been maintained primarily by prescribed burning.

A plan to continue converting half of extant Refuge grassland to forest was proposed in 1984, but not approved, and instead a decision was made to rehabilitate existing grasslands and reclaim additional grassland habitats through timber removal and fire use. In 1981, a prescribed fire program was initiated as a tool to maintain and rehabilitate grasslands. The primary goal of the current Grassland



Tamarac NWR wetland. Photo Credit: George Read

Management Plan (1990) was to provide a variety of quality grasslands, by 1999, totaling 2,500 acres and eventually 5,000 acres for the benefit of nesting waterfowl. Additional goals were to:

1. Strive for a 4.6 to 1 forest to grassland ratio which would represent habitats observed by Refuge founders.
2. Provide habitat suitable for reestablishment of Prairie Grouse populations, either by natural immigration or eventual restocking
3. Provide openings in unbroken forest cover to benefit Woodcock, deer, grouse and other resident wildlife.

Many grassland areas are small and scattered throughout the Refuge. These patches are too small to be of value to most area-sensitive grassland bird species and some upland nesting waterfowl due to their juxtaposition in a forested landscape. Currently, there are 83 designated grassland units on the Refuge with an average size of 17 acres (median of 7.6 acres). Sixty-eight percent (57 of 83) of these grassland units are less than 20 acres in size, and only ten of these grasslands are greater than 40 acres in size with the largest tract consisting of 88 acres. Historically, there probably was not any upland grass habitat at the Refuge during the era immediately prior to European settlement. However, grass/brush habitats would likely fall within the range of natural variability due to catastrophic disturbances and may have been present for short periods of time until succession quickly progressed.

The 1000-acre Tract

One attempt to create a sizeable, contiguous unit of grassland/brushland that could be managed long term by prescribed fire to enhance habitat for upland nesting ducks, especially Mallards, and recolonization of Prairie Grouse was conceived through establishment of the 1,000-acre Tract. Following the logging of the native red and white pine stands in the late 1800s, subsequent fires and settlement of the Refuge, Pinnated and Sharp-tailed Grouse were observed on the Refuge. The Pinnated Grouse persisted into the 1940s and Sharp-tailed Grouse until the 1950s when the developing second growth forest closed in eliminating suitable habitat for them. Nearly a hundred years later (late 1980s) significant portions of the 1,000-acre Tract were logged a second time. This tract was a forested/wetland area in the central portion of the Refuge that was cleared of most the trees by 1990 to create a brushy grassland area of 1,000 acres that would be burned at least 3 times from 1990-1995 to kill woody regeneration and to stimulate native grasses and forbs on uplands, as well as kill willows, create open

water for pairs [waterfowl] and enhance marsh vegetation in wetlands.

This tract was chosen because of the relative openness of the area and the presence of a remnant parcel (52 acres) of native big bluestem that suggested that the area historically developed under some open landscape conditions. The relative openness of several other anthropogenic grassland fields that were already established adjacent to the unit was significant in the tract's selection. Indeed, recent research indicates this 52-acre remnant parcel developed under "open" grassland conditions, but this was the only area within entire 1,000-acre Tract indicative of this condition. In addition, most experts would agree that big bluestem is ubiquitous to a variety of habitat types including forest habitats in northern Minnesota.

Prior the creation of the 1000-acre Tract, the unit was dominated by aspen with varying densities of mature burr oak and scattered white and red pines present within the stands. Also present on the higher ridges was a closed canopy community of jack pine with paper birch inclusions. A complex of more than 100 wetland basins and 52 acres of old settler field openings were also present. Logging excluded many of the oaks and large red and white pines along the ridges. These trees were left as future seed trees should Prairie Grouse not return.

Essentially, this management adopted a "cookie-cutter" approach where a block of forest habitat was fragmented within an interior forested landscape. The intensity and timing of prescribed burns have only stimulated the shrub species present on the unit rather than eliminated or reduced them as originally intended. Overall, this tract is not contributing greatly to regional or even local waterfowl



Tamarac NWR. Photo Credit: FWS

populations. Tamarac NWR is positioned in a forested landscape and Sharp-tailed and Pinnated Grouse have not pioneered or re-established into the area. A new management scenario for this area, either through natural succession or active restoration, will be considered in this CCP.

Forest Openings

Thirty-two forest openings, totaling 63 acres, were established in the northern portion of the Refuge from 1990 to 1991. These openings are very similar to the smaller grassland units mentioned previously but are smaller in size. The openings were typically placed in a variety of forest types and generally centered on recently abandoned logging decks and ranged in size from 1 to 3 acres with an irregular shape. In most cases, these openings represent a “hard edge” or transition from grass to forest without much woody vegetation within the opening itself. These openings were created out of a need to provide early successional stages and edge habitat within a continuous forest habitat primarily for the benefit of ruffed grouse, woodcock, bear and white-tailed deer.

Maintenance of these openings included tree removal, prescribed fire, herbicide, tillage, grading, mowing and seeding to stop woody invasion. Prescribed fire, herbicide and mowing have been the primary treatments in recent years, although invasive species, particularly thistle species, have invaded many of these openings thus requiring additional mechanical or chemical treatment. With limited budgets, these openings can be very costly to maintain. There are enough natural openings on the landscape; therefore anthropogenic openings do not need to be maintained. The natural openings on the landscape provide enough habitat on the landscape for these relatively common species and the Refuge should focus on maintaining “unbroken” or non-fragmented forest habitat. Temporary openings created through on-going silvicultural practices on the Refuge provide the same amount of habitat if not more at no additional cost to the Refuge and require no maintenance.

Croplands

Similar to the “edge-management” philosophy of the grasslands, wildlife biologists (particularly waterfowl managers) for decades encouraged the cultivation of crops, particularly grains, as a nutritious food source both for upland game and migrating ducks and geese. When national wildlife refuges were established, agricultural lands were acquired and often maintained to produce food for wildlife. However, by the 1980s, wildlife biologists generally, and the U.S. Fish and Wildlife Service specifically, were adopting more holistic approaches to wildlife management. They realized that artificial food pro-

duction often had undesirable outcomes even among those species targeted to benefit, such as overpopulation or overcrowding and thus susceptibility to disease and other problems, e.g., outbreaks of botulism or avian cholera.

At the same time, croplands often came at the expense of more robust, sustainable, and diverse natural communities and the non-game organisms that inhabit them. In recent years, the Service and wildlife biologists in other agencies have tended to discourage grain and crop cultivation. Today, only one small cropland field is maintained on the Refuge for the benefit of watchable wildlife. It is located off the Blackbird Auto tour route. All other cropfields within the Refuge have been converted to grassland, many of which will ultimately be converted to forest. In recent years, the management philosophy at Tamarac NWR, paralleling that of other refuges around the country, has become more oriented toward fostering or simulating natural processes, like wildland fire, to achieve desired landscapes and to restore scarce habitats.

Forest Management

The long range goal identified in the current Forest Management Plan (USFWS 1994) was to provide diverse patterns of vegetation and openings throughout the entire Refuge. The goal was to be accomplished through management ranging from preservation to very active forest management via timber harvest to promote early successional stages. In general, the current purposes of forest management are to provide protection and generate new habitat areas for endangered species, as well as managing for a variety of forest species, through the use of sustained yield principles of forest management. Under the 1994 plan, the development of open crowned canopies and block clearcuts to provide habitat for a diversity of wildlife was promoted, along with the growth and retention of abundant tree cavities for cavity nesting waterfowl and other birds.

Management of upland and lowland hardwoods was to be directed toward mixed, uneven-aged stands with all age classes represented to insure a continuous supply of natural cavities. From the mid-1980s through the late 1990s, timber harvest of aspen on the Refuge was accelerated due to an increase in aspen pulp markets. From 1987 to 1990, over a thousand acres of aspen was harvested per year, primarily through clear-cutting practices. In order to alter the age class diversity, some of these aspen regenerating sites were mowed with a hydroaxe or knocked down with a roller chopper; however, this practice was fairly limited. Forest management objectives associated with these efforts were primarily concerned with managing for



Winter day at Tamarac NWR. Photo Credit: Pam Lehmann Callaway

early successional habitats on a rotational basis for Golden-winged Warblers, American Woodcock and Eastern Towhee. Timber harvest of mixed upland hardwoods was through selective harvest techniques where single trees or clusters of trees were harvest from within a larger stand of trees.

Some clear-cutting of decadent jack pine occurred in recent history, followed by prescribed fire in an attempt regenerate jack pine. These efforts were met with limited success. Selective harvest of red pine occurred infrequently as well, primarily as a thinning operation to increase basal area of the remaining red pines. For the most part, white pine has been preserved on the Refuge to provide nesting trees for bald eagles. Although harvest strategies exist in the Forest Management Plan for lowland hardwoods and lowland conifers, these cover types have been left relatively undisturbed. Specific management strategies for each of the major cover types were identified in the 1994 plan.

Representative areas of all forest cover types were allowed to succeed to mature forest with no active management in an effort to insure the needs of all wildlife species were being considered. These specific areas include the Wilderness Area, Research Natural Areas and “Old Growth Unit”. Although the “Old Growth Unit” really does not meet true old growth criteria in a true sense of the term, it was an area set aside to be managed as a diverse forested area which possesses a high probability of becoming, over time, acceptable habitat for interior forest birds.

Currently, there is no mandate that the NWRS harvest trees or manage specifically for timber pro-

duction. The Refuge has the unique opportunity to manage the land for wildlife management purposes, which may include various management strategies such as preservation, timber harvesting, prescribed fire, etc. The 1997 Refuge Improvement Act and subsequent Biological Integrity policy provide the foundation for this determination, along with the land’s inherent capability.

The distribution and abundance of cover types are significantly altered from pre-settlement times primarily due to timber harvest, farming, grazing and fire suppression. Consequently, in many forest patches, the compositional and structural patterns that now exist are considerably different relative to pre-European benchmark conditions. For example, many of the timber harvest efforts on the Refuge have converted climax communities or later seral stages to early successional stages. Subsequent management has attempted to maintain them at the young stage while fire suppression has essentially eliminated a natural process within fire dependent plant communities. These efforts have created an imbalance of cover types within the native plant communities in relation to the range of natural variation.

Although forest communities have changed in composition across much of northern Minnesota, opportunities exist for sustainable management and conservation of these communities. Large tracts of native plant communities provide opportunities for ecosystem management, through silviculture, fire and hydrological management that mimic natural cycles in forests and forested wetlands, thereby, perpetuating all of the beneficial functions that native plant communities provide. Specifically, on Tamarac NWR management efforts include the restoration of these native plant communities, including the composition, structure and ecological processes associated with these communities.

Habitat Restoration

Many of the management efforts on the Refuge focus on restoring ecosystems, wildlife habitats and populations that have declined or have been completely lost. Since the inception of the National Wildlife Refuge System’s biological integrity policy in 2001, increasing emphasis has been placed on restoring native ecosystems and their associated natural processes. Where feasible, management that restores or mimics natural ecosystem processes or function to achieve Refuge purpose(s) is favored; however, it may be necessary to modify the frequency and timing of natural processes at the Refuge scale to fulfill Refuge purpose(s) or to contribute to biological integrity at larger landscape scales. Endangered plants and animals, as well as rare communities, are the highest contribution that

Tamarac can make to preservation of local and landscape levels of biological integrity.

The boreal hardwood forest in Minnesota, particularly the coniferous component, is becoming a rare and unique habitat and the preservation and restoration of these systems helps the Refuge adhere to the biological integrity policy. Restoration of endangered species (ie: Bald Eagles and Trumpeter Swans), as well as rare communities (ie: jack pine barrens, red and white pine cover types, etc), has and will continue to be at the forefront of management at Tamarac. The majority of the habitats on the Refuge have been modified by humans to some extent; however, most of these habitats are not degraded and could be managed as intact ecosystems, with potential for restoration near the historic range of natural variation rather than an arbitrary point in time, such as pre-settlement conditions.

Given the continually changing environmental conditions and landscape patterns of the past and present (e.g., rapid development, fire suppression, climate change), relying on natural processes may not be feasible or always the best management strategy for conserving wildlife resources. Uncertainty about the future requires that a refuge manage within a natural range of variability rather than emulating an arbitrary point in time. This approach maintains processes that allow species, genetic strains, and natural communities to evolve within changing conditions, rather than trying to maintain stability.

Fish and Wildlife Management and Monitoring

Fish and Wildlife Management

Fishery Management

The goal of the Refuge fisheries program is to provide and maintain a diverse, yet balanced, fish population capable of supporting a quality sport fishery. Lakes currently supporting catchable sizes of game fish (and open to public fishing) in most years include: Lost, Two Island, Wauboose, Blackbird, North Tamarac and Pine. The Minnesota DNR currently stocks Wauboose and North Tamarac Lakes with walleye fry on an every-other year cycle. Likewise, the White Earth Tribal Natural Resources Department stocks walleye fry in Lost and Teacracker lakes on a similar cycle. The Minnesota DNR and White Earth Tribal Natural Resources Department routinely conduct fish surveys on these lakes that are stocked. The LaCrosse Fisheries Resource Office (USFWS) has conducted fish survey assessments on some of the other priority lakes within the Refuge on a five year rotation.

Wildlife Management

Wildlife population management is predicated on the fact that habitat is the most critical factor limiting a desired species response. Therefore, most refuges focus on managing the habitats rather than the wildlife species. Wildlife management on national wildlife refuges has evolved “from managing for a few species to managing for many species using natural processes” (U.S. Fish and Wildlife Service 1999). Today, many refuges focus on restoring land to certain desired conditions through direct habitat management for the benefit of wildlife, rather than setting specific population objectives. Emphasis is placed on maintaining or restoring native plant communities that sustain the area’s biological diversity at the landscape scale.

Predator and Exotic Wildlife Management

Tamarac NWR has a trapping program, administered through a 1991 Trapping Plan, with the primary purpose to control predation on ground-nesting birds. Trapping also helps control the number of muskrat and beaver which cause damage to roads and water control structures. The plan provides specific guidance for administering the recreational/commercial trapping program of the White Earth Band of Objiva on the Refuge, and contains guidelines for other trapping by Refuge staff or other permittees.

The Refuge has a trapping history that dates back to the time of Refuge establishment. Starting around 1975, the program was modified such that only enrolled members of Minnesota Objiva were able to obtain a permit. Non-tribal members may be offered trapping opportunities if the alternate list of tribal applicants is exhausted (pending Refuge manager discretion). Trapping of beaver, muskrat, mink, raccoon, red fox, coyote and otter is authorized under the trapping plan. Low fur prices in recent years have diminished interest in trapping on the Refuge and as a result fewer furbearers have been taken in recent years. Beaver and muskrat comprise most of the harvest on an annual basis.

The Refuge is divided into seven zones with only one authorized trapper per zone. On those portions lying within the White Earth Reservation, permittees are governed by seasons, bag limits, methods of take and license requirements established by the White Earth Tribal Council. On the remainder of the Refuge, regulations of the Minnesota DNR are applicable. The trapping season typically runs from mid-October through April each year.

Fish and Wildlife Monitoring

In support of the Service’s mission, the National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System

Improvement Act of 1997, specifically directs the Service to “...monitor the status and trends of fish, wildlife, and plants in each refuge.” It is nearly impractical for most refuges to monitor all species within a given refuge, therefore refuges must prioritize monitoring efforts. Ideally, guidance for prioritizing inventory and monitoring is derived directly from management objectives established in the CCP and HMP, which incorporate the Refuge System mission, refuge purpose, the refuge’s role as a part of the NWRS, refuge resources of concern (both wildlife and habitat), ecosystem function and integrity (i.e.: native plant community intactness and their natural processes), and the context of the surrounding landscape.

The Refuge staff currently conduct approximately 33 surveys on an annual basis that are guided through an approved 1992 Inventory and Monitoring Plan (IMP). The station’s IMP identifies and prioritizes survey objectives and includes a set of approved survey protocols.

Four basic types of inventories are conducted on Tamarac NWR:

- basic species lists through presence/absence detection
- qualitative surveys lacking statistical vigor
- quantitative surveys characterized by a high level of statistical vigor
- cooperative surveys which follow predetermined protocols established by their respective coordinating offices or agencies.

The surveys within the Refuge’s IMP are generally conducted by Refuge staff with some assistance from Refuge volunteers.

Studies and Investigations

The intent of additional studies and investigation beyond routine monitoring is to promote research (or investigation) that relates to a specific refuge management concern and uses the results to inform management decisions (applied research). Tamarac NWR recognizes the important and much needed role research has in the management of federal lands. The following paragraphs describe a few of the studies and investigations (research) that are either ongoing or have taken place in recent years.

Water Quality

To address water quality concerns, the Refuge initiated a water quality monitoring program in 2007.

Currently, the Refuge, in cooperation with the Tamarac Interpretative Association and Minnesota Pollution Control Agency, monitors various water



Obtaining lake samples for the Tamarac NWR water quality monitoring program. Photo Credit: FWS

chemistry parameters for 11 lakes and 7 stream sites within the boundaries on a weekly basis throughout the ice-free period. These water quality assessments are also incorporated in evaluation of the water quality in the entire Red River Basin.

Climate Change

In 2009, the Refuge joined a partnership with the Terrestrial Wetland Global Change Research Network (TWGCRN) via Upper Midwest Environmental Sciences Center (UMESC) to begin to address the needs of the FWS and the Refuge regarding climate change and understanding effects and options within regional, national, and international contexts. Tamarac NWR functions as a research node in the TWGCRN, a growing network of U.S. and Canadian scientists, organizations, and research sites using multidisciplinary methods to assess the impacts of climate change across a vital portion of North America and management options for mitigating negative effects. The primary objective is to implement a long-term, integrated assessment of the effects of climate on a set of indicators of landscape conditions at Tamarac NWR via installation of digital sound recorders, water-level loggers, and temperature loggers at ten individual wetlands. This study allows the Refuge to obtain crucial information on the status of Refuge biodiversity (using birds and amphibians as indicators) relative to climatic, hydrologic, and habitat conditions inside and outside the Refuge. It enables the Refuge staff to manage terrestrial and aquatic conditions within the Refuge to maximize conservation benefits and to identify essential habitat connectivity to areas outside the Refuge so Refuge staff can collaborate with



Cleaning out a culvert plugged by beavers. Photo Credit: FWS

partners and landowners to maximize conservation benefits at larger landscape scales.

Pathways for Ecological Restoration of Native Plant Communities

In 2009, Tamarac NWR initiated a project through Wildlands Ecological Services, which used the Minnesota Ecological Classification System (ECS) to determine the distribution of native plant communities (NPC) within the Refuge in an effort to assess the restoration potential, including ecological processes associated with those communities.

An important consideration within ECS is the inclusion of ecological processes as an organizing principle (e.g., fire regime, successional or seral stage, hydrology, etc.). Instead of basing management decisions solely on cover types or other single attributes, ECS will enable Refuge staff to understand how a variety of conditions are interacting and the site potential that results from those interactions. The expected completion date for this project is March 2011.

Survivability of Spotted Knapweed Biological Agents to a Spring Prescribed Fire

A graduate student from the University of Wisconsin–Green Bay, initiated a study in 2006 to examine the “Survivability of Spotted Knapweed Biological Agents to a Spring Prescribed Fire”. As land managers began to integrate biological control agents into their weed management programs, questions arise to whether or not prescribed fire has an effect on these agents. Tamarac NWR is one of six study sites distributed between Minnesota and Wisconsin. Areas were sampled for spotted knapweed bio-agent densities and vegetative cover before and after burn treatments. Preliminary results indicate that soil and unburned areas provide refugia from low intensity fires, thus there appears to be no detrimental effect for most knap-

weed biological control agents. These results will be used to formulate a more comprehensive integrated weed management scheme for spotted knapweed control in grassland systems, incorporating prescribed fire, biological control, and cultural methods to decrease the time-lag in site restoration.

Golden-winged Warbler Breeding Ecology

Tamarac NWR launched a multi-year research study in cooperation with Concordia College to:

- Assess the cumulative contribution of small isolated patches of Golden-winged Warbler habitat to the overall population on Tamarac NWR.
- Develop a fine-scale model of Golden-winged Warbler habitat selection on Tamarac NWR.
- Document seasonal changes in breeding ecology.
- Evaluate the detection area correction factor (“listening distance”) established by Partners in Flight for estimating the population of Golden-Winged Warblers throughout the continental U.S.

In May 2010 project was near completion.

The University of Minnesota-Crookston launched a similar project examining Golden-winged Warbler ecology and management. This effort is through a comprehensive approach coordinated through collaboration of federal and state agencies, academia and industry stakeholders across the breeding range of the Golden-winged Warbler. The primary objective is to examine responses of Golden-winged Warblers and associated species to a host of early successional habitat types and conditions with the goal of developing suitable habitat management prescriptions.

In addition, researchers hope to document genetically pure-populations by developing a genetic atlas. Tamarac NWR is one of seven studies monitored across the breeding range. Basic demographic data (return rates, territory size, clutch size, nest success, young produced per successful nest, annual reproductive output, parasitism rates and hybridization rates) is currently being collected in New York, West Virginia, Pennsylvania, Tennessee, Wisconsin, Michigan and Minnesota. The study is scheduled to be completed by December 2010.

Post-fledging Ecology of Ring-necked Ducks in Minnesota

The Minnesota DNR Fall Use Plan recognized sizable populations of resident breeding ducks as a cornerstone to improving fall duck use. Although breeding Ring-necked Duck (*Aythya collaris*) populations have been increasing continentally, they

appear to be declining in Minnesota (Zicus et al. 2005). Factors influencing resident populations are poorly understood, and efforts to better understand their status began in 2003 with development of a breeding-pair survey for Ring-necked Ducks in Minnesota. Minnesota's Fall Use Plan identified the need to better understand the role of refuges in duck management. The influence of north-central Minnesota refuges on the distribution and welfare of resident Ring-necked Ducks is largely unknown, as well as the influence that the distribution of the resident population might have on that of migrant Ring-neck Ducks arriving in the fall.

The intent of this project is to relate the distribution and welfare of a local population of ducks to the pattern of refuges existing in north-central Minnesota. Understanding factors influencing the distribution of locally raised Ring-necked Ducks in the fall may provide valuable insights into the distribution of refuges required to meet management objectives for Ring-necked Ducks in Minnesota.

Incorporating the aid of radio telemetry, the objectives of this study were to:

- Characterize post-fledging movements of local Ring-necked Ducks prior to their fall departure
- Estimate survival of locally produced birds during this period
- Relate the survival of locally produced birds to their relative use of or proximity to established refuges (federal and state) in north-central Minnesota.

Tamarac NWR is one of two federal refuges and 12 state refuges involved in the study which encompasses a significant portion of the core of the Ring-necked Duck breeding range in Minnesota. The project is scheduled to be completed in December 2009.

Disease Monitoring and Control

West Nile Virus

West Nile Virus appeared in northwestern Minnesota in 2002, reported first in horses. Spread by mosquitoes, this exotic virus infects mammals, including humans, and birds. Members of the Corvidae family (crows and jays) seem to be especially vulnerable.

Avian Influenza (H5N1)

Avian influenza, the H5N1, highly pathogenic strain of "bird flu," has received a great deal of attention in recent years. It has not yet been detected in North America, but because migratory waterfowl, shorebirds and other birds could potentially introduce the virus, an early detection sampling strategy was developed. The Refuge has



Visitors discover turtle egg shells on a wildlife excursion. Photo Credit: FWS

participated in surveillance monitoring efforts of this disease from 2006 to 2009 primarily by collecting cloacal and/or oropharyngeal during waterfowl banding activities. Primary targets sampled include Mallard, Green-winged Teal and Wood Ducks. All samples were submitted to the USGS National Wildlife Health Center located in Madison, Wisconsin for analysis.

Visitor Facilities

Visitor activities on Tamarac NWR vary with the season (see Figure 12 on page 48 and Figure 13 on page 49).

Hunting

Hunting on the Refuge is very popular with local residents and many visiting hunters. All hunting is done in accordance with federal, state, and White Earth tribal regulations and seasons. A 1,350-acre area surrounding the Refuge Headquarters and Visitor Center is closed to hunting.

White-tailed deer are hunted during the state firearms and archery seasons. The Refuge is identified as a separate harvest unit by the Minnesota Department of Natural Resources.

The most popular small game is Ruffed Grouse, with gray and fox squirrels, cottontail rabbit and snowshoe hare also pursued by hunters. Migratory birds including ducks, Canada Geese, American Woodcock and Common Snipe are hunted during the established fall seasons. The Refuge is open to a special state youth waterfowl hunt every year.

Fishing

Fishing is a popular activity in this region of Minnesota and on Tamarac NWR as well. Regulations of the Minnesota Department of Natural Resources and, where applicable, the White Earth Reservation

Figure 12: Current Visitor Services Facilities – Fall and Winter

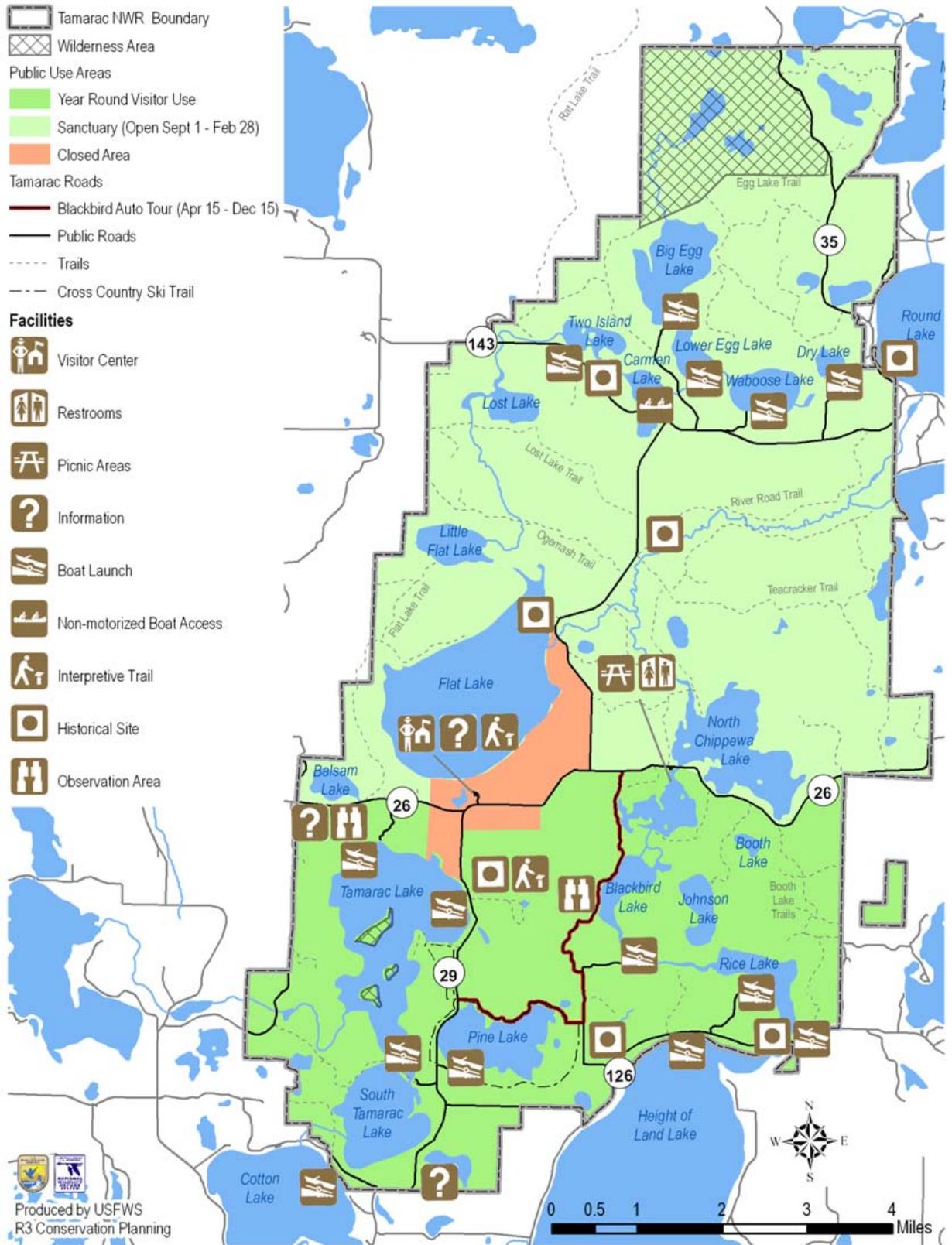
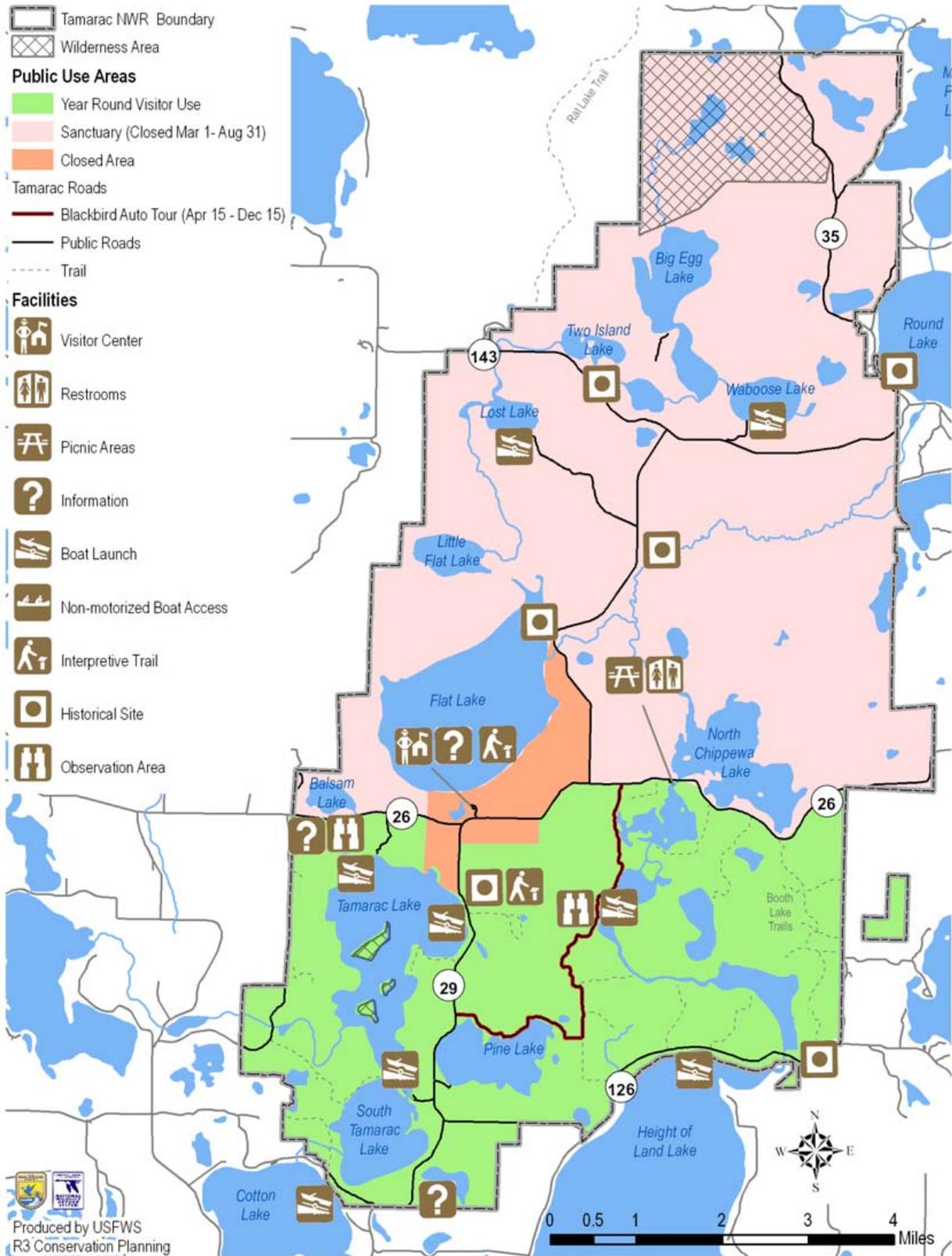


Figure 13: Current Visitor Services Facilities – Spring and Summer



are in effect regarding licensing, creel limits, tackle restrictions and season. Anglers pursue northern pike, walleye, largemouth bass, bluegill, pumpkinseed, black crappie, yellow perch, black, brown, and yellow bullhead and white sucker.

Several lakes are open for fishing throughout the year. Two sites along the Otter Tail River are also open for bank fishing. The following sites are open to fishing on the Tamarac NWR:

- North Tamarac, Wauboose and Two Island Lakes are open year-round.
- Blackbird and Lost Lakes are open only during the state season- mid-May through Labor Day
- Pine Lake is open to ice fishing from December 1 to March 31.
- Bank fishing 50 yards either side of Otter Tail River bridges on County Roads 26 and 126 is permitted. No additional river areas are open to fishing.

Wildlife Observation

Tamarac NWR is known as a great place to watch wildlife and it is recognized internationally for its importance as a migratory bird stopover. Each year, visitors from around the world come to the Refuge to observe wildlife. The road network and waters provide excellent opportunities for people, of all ages with various abilities, to observe wildlife. Others prefer to walk the nature trails or hike in search of wildlife. During the winter, visitors can get into cross-country skis or snowshoes to observe wildlife.

Staff and volunteers working at the Visitor Center maintain a wildlife observation log and share that information with visitors. Staff also help visitors locate observation decks with viewing scopes. Tours are given periodically that provide viewing opportunities into the back country.

Wildlife Photography

The trails and observation platforms along the lakes and rivers affords photographers, of all skill levels, excellent opportunities to photograph wildlife. Many beginners focus their lens on the ever charismatic Trumpeter Swan or state flower, the showy lady-slipper, as is evident by entries to the annual Tamarac NWR Photo Contest. The more seasoned photographers often venture beyond the auto tour route to capture images of plants, insects, and landscapes bathed in a wide spectrum of light conditions.

Interpretation

The Refuge Visitor Center, open year-round, contains a variety of displays to interpret the natural resources of Tamarac NWR as well as the bio-

logical work conducted on the Refuge. It contains permanent exhibits including a forest and wetland wildlife diorama that features wolf, beaver and eagle's nest. Exhibits also include vernal ponds, Ruffed Grouse, and wildlife sounds of the Refuge. Creative temporary displays and video monitors are used to inform the visitors of what's blooming, who is migrating, the use of fire management, the threats of invasive species and other Refuge management activities.

Refuge kiosks provide interpretive information on the Fish and Wildlife Service and specifically Tamarac NWR. The Blackbird Auto Tour Drive has an interpretive brochure for stops along the route and an observation platform was built with a focus on eagles and wild rice. Fact sheets and posters also provide additional interpretive information.

Special events, held throughout the season, provide interpretive information on a variety of topics such as hunting and fishing, endangered species backyard wildlife, migratory birds, fire ecology, invasive species management, wildflowers and wildlife films.

The Refuge's interpretive program reaches beyond the Refuge boundaries. Events in the community and presentations to civic groups are all part of the outreach efforts. Some of the events sponsored in recent years include:

- National Wildlife Refuge Week which includes a Fall Festival event and a variety of interpretive programs
- Detroit Lakes Festival of Birds
- Winter Open House

The Refuge's interpretive program is subsidized by funds from Tamarac Interpretive Association. The Tamarac Interpretive Association has also paid for the publication of brochures and signs as well as the construction of observation decks. A majority of their funds are derived from the sale of books, Refuge-specific clothing and interpretive material sold in a small store located in the Visitor Center.

Environmental Education

The Refuge welcomes school groups and others interested in environmental education. On average, 2,000-3,000 students visit the Refuge each year, with many returning several times over the seasons. School field trips are accommodated through guided activities including data collection of habitats, tree planting, and nature observations. In recent years, home-schooled students are frequent visitors. The Refuge has a variety of lessons that address state graduation standards and the Fish and Wildlife Service mission. There is a growing demand for environmental education both on and off Refuge.

Outreach

The Refuge is an integral part of the surrounding communities. It plays a role in the communities' tourism through recreation, is an outdoor classroom for local school districts, and is at the headwaters of two major watershed districts. The Refuge is part of the Pine to Prairie Birding Trail, North Country National Scenic Trail and the Lake Country Scenic Byway. All of these connections and more have created extensive partnership opportunities to enhance the biology and interpretive efforts on a landscape scale beyond the boundaries of the Refuge. Refuge staff regularly work with Chambers, local officials, civic groups, agencies and organizations that have similar goals.

Interpretive efforts to connect local residents with biological activities and wildlife management practices extend to regular newspaper articles, radio and tv broadcasts. Off-site presentations to civic groups and others are also an important means to strive for local communities to recognize refuges as national treasures, understanding the System's tremendous contribution toward wildlife conservation and actively participating in their stewardship.

Volunteer Contributions

The Fish and Wildlife Act of 1956, as amended by the Fish and Wildlife Improvement Act of 1978 and the National Wildlife Refuge System Volunteer and Community Partnership Enhancement Act of 1988, authorized the Service to accept volunteer services. Congress reauthorized the Volunteer and Community Partnership Enhancement Act in 2004, affirming its desire to involve Americans as stewards of our nation's natural resources and wildlife. As a result, the Refuge System expanded its volunteer program, environmental education programs, recreational opportunities, and community-based partnerships increased.



White-tailed deer welcome visitors. Photo Credit: Dick Henry

The expanding volunteer program at Tamarac NWR includes more than 100 volunteers, both individual and group, that donate more than 6,000 hours to the Refuge. Tamarac NWR volunteers are individuals who want to give back to their community, parents and grandparents wanting to model environmental stewardship, retirees willing to share a wealth of knowledge, concerned citizens of all ages who are interested in making meaningful contributions while learning about conservation, and passionate people who enjoy the outdoors and want to spread the word about Tamarac NWR and its greatest natural treasures. Volunteers on the Refuge assist with providing information to the public at the Visitor Center, environmental education activities, interpretive and outreach programs as well as administrative tasks. They are photographers, equipment operators, and journalists. They get involved in habitat restoration efforts, biological programs and maintenance tasks. Volunteers of Tamarac NWR become advocates in the community for Refuge management actions and provide vital help in fulfilling the Refuge mission.

Partnerships

Tamarac NWR staff invest a significant amount of energy and time representing the Refuge in its role as a partner with other government and resource agencies as a neighbor and large landowner in the community. Refuge staff participate as team members of various committees and groups ranging from watershed districts to Minnesota tourism promotion efforts.

Interagency Coordination

Tamarac NWR staff work closely with professionals from the various conservation agencies to ensure the continued resilience of the natural resources to environmental challenges.

- Assist U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) and local county soil and water conservation districts with Farm Bill program implementation.
- Participation in Buffalo-Red River Watershed meetings.
- Collaboration on water quality issues with the Red River Basin Water Quality Team, which advises Minnesota Pollution Control Agency on water quality management, improvement and protection strategies for the watersheds of Minnesota's Red River Basin.
- Cooperation with the U.S. Department of Agriculture and the Minnesota Department of Agriculture on invasive species monitoring and management, including use of biological control



White Earth tribal members harvest wild rice. Photo Credit: FWS

agents, establishment of insectaries, and infestation monitoring.

- Coordination on a wide variety of surveys, studies and restoration efforts with outside parties including the U.S. Forest Service, Minnesota DNR, Pelican River Watershed District and U.S. Geological Survey.

Tribal Activities

Tamarac NWR maintains a special relationship with the White Earth Reservation. The north half of the Refuge lies within the original boundary of the White Earth Indian Reservation, established in 1867. A unique agreement referred to as the “Collier Agreement” was instituted during Refuge establishment. This agreement affords White Earth band members priority privileges to trap furbearers and harvest wild rice on the Refuge (see Appendix H). Over the years, the Refuge and White Earth Natural Resources Department have forged a strong cooperative relationship managing these two activities.

Trapping: A drawing for up to seven trapping permits is conducted every October at Refuge headquarters. The Refuge is divided into seven separate trapping zones that have been historically reserved for tribal members only. The White Earth Reservation Tribal Council establishes seasons and regulations for trap zones within the reservation boundary

of the Refuge. The state enforces state seasons and regulations outside the reservation boundary. In addition, Refuge Special Use Permit regulations further control trapping activities, such as limiting motorized vehicle use to protect habitats and minimize disturbances and imposing more restrictive snaring regulations to prevent accidental catch of gray wolves. The Refuge trapping season runs from October through April 30 each year. The most common furbearers harvested are beaver, otter, muskrat, mink, raccoon, and red fox. Drawing attendance, trapping effort, and success varies greatly year to year depending on fur market futures. Over the past 20 years, harvest rates have averaged approximately 330 furbearers per year. Beaver are the most sought after species representing 57 percent of the harvest over this period.

Tribal wild ricing: The White Earth Natural Resources Department (WENRD) hosts a Refuge permit drawing for wild rice harvest every August. Two to three hundred tribal members attend the drawing each year. The number of permits issued is based on the abundance, quality, and distribution of the wild rice beds within the Refuge. A WENRD staff annually assesses wild rice production on the Refuge and determines how many boats each lake or stretch of river can sustain. Refuge permits have been reserved for White Earth enrolled members and are issued per boat (two people per canoe). Over the past 10 years, boat numbers and open waters have ranged from 49 to 95 boats on 9 to 15 lakes and rivers. After the WENRD opens Lower Rice Lake, in Clearwater County, to wild ricing, the Refuge issues additional permits to enrolled members. Ricing season normally begins in late August and concludes by mid-September. The Refuge assists with the drawing, issues permits, and mows trails and boat landings for access. In addition to sponsoring the drawing and managing the harvest, WENRD also keeps boat landings clean, opens and closes trail gates, and posts required notices.

Other activities outside the scope of the Collier Agreement include:

Leech harvest: Beginning in 1987, the Service has permitted commercial leech harvest on the reservation portion of the Refuge for enrolled White Earth band members. The WENRD holds a drawing for four leech trapping zone permits. The event is annually attended by 150-250 tribal members. Tribal interest is high due mostly to the Refuge’s Mallard Lake which has produced as many as 8,200 pounds of leeches in a single year. Bait vendors typically pay \$4 to \$12 per pound. Similar to wild rice, leech harvest success is quite variable and has ranged from 1,200 to over 8,700 pounds over the past 20 years. Leech harvest is open from ice out through the end of August. Compared to other

tribal activities, adherence to permit requirements has been very poor, in particular, the problem of personal property abandonment on Refuge lakes and wetlands. Other concerns have been raised regarding impacts this activity has on wildlife, such as disruption of Trumpeter Swan nesting and the take of snapping turtles that destroy leech bags.

Hunting and fishing: The Refuge and White Earth Natural Resources Department cooperatively manage tribal hunting and fishing over the reservation portion of the Refuge.

Other requested uses: The Refuge controls access to closed areas and also issues Special Use Permits on a case by case basis for other requested uses, such as collection of plants for medicinal use.

Cooperating Organizations

Tamarac NWR partners with several organizations on efforts of mutual interest.

The Refuge friends group, Tamarac Interpretive Association (TIA), was established in 1992 to serve as an advocate of Tamarac NWR and the Service. The mission of TIA is to facilitate activities and programs that interpret, protect and restore the natural and cultural resources of the Refuge. The Tamarac Interpretive Association also raises funds and offers volunteer support for conservation work that might otherwise go undone. Through a cooperative association agreement, the group runs the Wildlife Gifts and Book Store in the visitor center. Store items offer visitors a variety of books, videos, and tools that help educate and engage people with the Refuge. The group provides funding for educational supplies, biological work and more. TIA assists with recruiting volunteers for environmental education, interpretive programs, events, biological and maintenance activities on the Refuge. TIA is an essential link to the community as they foster rela-



Trumpeter Swans. Photo Credit: Greg Stetz

tionships with community leaders, businesses and organizations promoting the mission of the Service and stewardship of Refuge lands.

Tamarac NWR staff are involved with the Pine to Prairie Birding Trail, a unique partnership between the NW Minnesota communities of Detroit Lakes, Fergus Falls, Pelican Rapids, Roseau, Thief River Falls and Warroad; participating agencies U.S. Fish & Wildlife Service, Minnesota Department of Natural Resources Non-game Wildlife Program, Explore Minnesota Tourism; the birding entities of the Minnesota Ornithologist's Union, Audubon Minnesota, Lakes Area Birding Club and the Agassiz Chapter of the National Audubon Society. The birding trail is an exceptional opportunity to provide wildlife tourism opportunities and associated economic activity for visitors and residents of northwest Minnesota, while showcasing the tremendous natural resources of northwest Minnesota. In 2009, partnering with the Province of Manitoba, this trail expanded into Manitoba to create the newest international birding trail in North America.

Currently Tamarac NWR has strong partnerships with the universities, such as University of Minnesota – Crookston, University of Minnesota - St. Paul, Bemidji State University and Concordia University, to investigate resource management issues of the Refuge. Working with academia and college students at these universities also provides the Refuge an opportunity to aid in the development of individuals interested in pursuing careers in natural resource management.

Tamarac NWR works with several entities in the promotion of tourism opportunities in the surrounding area. These entities include, but are not limited to, Becker County Historical Society, Park Rapids and Detroit Lakes Chambers of Commerce, Lake Country Scenic Byway, North Country National Scenic Trail, Becker County Parks and Recreation, and the City of Detroit Lakes.

Tamarac NWR works closely with local area schools (Perham, Frazee, Detroit Lakes, Holy Rosary, Lake Park – Audubon, Waubun-Ogema-White Earth, Mahnomen, Pine Point, Naytahwaush, Moorhead, and Glyndon-Dilworth) to deliver standards-based environmental education programs for school age children. Other environmental educational opportunities are made available through Tamarac NWR's partnership with Natural Innovations, a community-driven organization committed to assisting individuals and organizations in developing a better understanding of how the health of humans and the environment are interrelated. Natural Innovations is comprised of environmental education professionals from local governmental agencies (Becker County Environmental Services,

Minnesota Pollution Control Agency, and Minnesota DNR), environmental businesses (RMB Laboratories) and citizen volunteers.

Tamarac NWR works with other non-governmental organizations, such as Duck Unlimited, Woodcock Minnesota, The Wildlife Management Institute, Ruffed Grouse Society, Minnesota Waterfowl Association, Becker County Sportsmen Club, local Lake Associations, and the Izaak Walton League in support of conservation initiatives such as habitat restoration, wetland protection, environmental education, water quality monitoring and public use opportunities.

Archeology and Cultural Resources

Evidence found on Tamarac NWR has revealed a rich history of human use by many cultures. Refuge staff strive to protect and to preserve archeological and historic sites against degradation, looting, and other adverse impacts.

Tamarac NWR has never been intensely surveyed for archeological resources. However, several site and project specific investigations have occurred on the Refuge. In addition, known archeological and historic sites were summarized and mapped in 1977 by two archeologists working under contract for the Service (USFWS 1977). This survey provided background on the periods of habitation in Minnesota and identified prehistoric and historic sites on Refuge lands.

Archeologists in Minnesota have divided prehistory into several cultural periods, based on the artifacts left behind by different human groups and the kinds of economic activities in which they were primarily engaged. In the Becker County area, these periods are: The "Paleo-Indian" (before about 5,000 B.C. commonly characterized by mammoth, extinct giant bison and other "big game" hunting, by nomadic groups using distinctively chipped stone spear points and tools); the "Archaic" (ca. 5,000 – 1,000 B.C.; adaptation to changing and increasingly diverse environments); the "Woodland" (ca. 1,000 B.C. – 1,400 A.D.; the advent of pottery, and the construction of earthen burial mounds, by seasonally nomadic groups who practiced some limited horticulture in southern areas of Minnesota, and began the intensive use of wild rice in northern areas); and the "Mississippian" (ca. 1,400 – 1,700 A.D.; influences coming into the area from more southern groups practicing organized horticulture, and generally living in large semi-sedentary villages in many parts of the American Midwest). These prehistoric periods are followed by the "Protohistoric" period (ca. 1,700 – 1,870 A.D.; beginning with the first White-European contact and continuing during the fur trade expansion) and the "Historic" period

(after 1,870 A.D.; the time of the European homesteading and the displacement of the Native American inhabitants).

In late prehistoric times, the Tamarac NWR area was occupied by the ancestors of the historic Sioux, or Dakota/Lakota, who were based in the Mille Lacs area and were in the process of fragmenting into the various historic bands when the French Jesuits and fur traders first arrived there at the end of the 17th Century. By the mid 1700s, the Ojibwe (or Chippewa) moved into Minnesota from the east as a direct result of the spread of the French fur trade. By 1800, the Ojibwe were known to hunt regularly in the plains areas west of the Mississippi. The Otter Tail Band of the Pillager Ojibwe was probably well established in the Tamarac NWR area before 1820.

The first documented European occupants of the area were traders of the Northwest Fur Company, who established a trading post at White Earth Lake in October, 1802. At about the same time, a small independent post at Shell Lake was started. However, actual European "settlement" did not occur in the region until around 1868. The logging industry made an appearance in Becker County relatively early, to take advantage of the expansive forest stands. Commercial pine and oak were probably first cut within the county by about 1870. By about 1908, the forests of the area had been extensively logged and the logging era ended. There were several attempts at farming within the Refuge, but farming never achieved much prominence due to the dense forest, marginal soils and numerous wetlands.

An inventory of archeological collections from Tamarac NWR was completed under contract by the Institute of Minnesota Archeology (1993). There have been five archaeological projects including reconnaissance and collections from Tamarac NWR since 1978, totaling an inventory of 1432 artifacts and ecofacts. Currently, these collections are being curated by the Minnesota Historical Society at Fort Snelling and the Department of Anthropology, Hamline University, St. Paul, Minnesota. Due to the overlap in habitation by both Ojibwe and Siouan speakers, most of the archaeological components present cannot be related to any particular historic tribe or tribal activity. There is evidence that a large number of historic Ojibwe sites are present within the Refuge, however, no cultural materials in the collections can be assigned to the Ojibwe.

From these reconnaissance projects, historic (post 1700s) and prehistoric sites have been identified. Among the historic sites, those associated with logging activities (road, camps, dams, and ditches) are most abundant. Other types include clearings, foundations, unidentified sites, settler's communities, bridges, cemetery or grave, standing struc-

tures, a CCC camp, and a school. Habitations comprise nearly one-third of the prehistoric sites, followed by seasonal camps. The remaining sites include trails, clearings, cemetery/grave, and unidentified sites. There are stone markers on the Refuge that identify some of these historic sites. The markers were placed in the mid-1960s with the cooperation of Becker County Historical Society and Minnesota State Historical Society.

Cultural resources management in the Service is the responsibility of the Regional Director and is not delegated for the Section 106 process when historic properties could be affected by Service undertakings, for issuing archeological permits, and for Indian tribal involvement. The Regional Historic Preservation (RHPO) advises the Regional Director about procedures, compliance, and implementation of cultural resources laws. The Refuge Manager assists the RHPO by informing the RHPO about Service undertakings, by protecting archeological sites and historic properties on Service managed and administered lands, by monitoring archeological investigations by contractors and permittees, and by reporting violations.

Law Enforcement

Federal and state laws and tribal conservation codes governing the Tamarac NWR are enforced to protect its priceless natural and cultural resources, facilities, other assets, and public visitors.

The Refuge currently staffs one dual function Refuge officer. The region's Zone Officer for Minnesota is stationed at the Refuge, lending enforcement assistance and guidance as needed. Formal and informal assistance agreements are in place with state and tribal officials to facilitate cooperation and effective law enforcement response to incidents and emergencies.

The primary mission of Refuge officers is to protect visitors, render aid and assistance, and deter or interdict criminal activity. Officer presence, recognition, and interface with the public provides not only the most effective method of soliciting voluntary compliance to Refuge regulations, but it also boosts visitor confidence and security, enhancing their Refuge experience. No regular patrols are scheduled, however officers do carry out tours of duty during high activity periods such as summer weekends, holidays, and popular hunting seasons. While the Refuge is regarded as a safe, low crime environment, officers frequently address a broad spectrum of incidents including accident investigations, citizen assistance, missing person searches, fishing and hunting infractions, trespass, and drug and alcohol violations.



Loon. Photo Credit: D. Braud

Of prominent importance are enforcement of federal statutes found under the National Wildlife Refuge Administration Act, Migratory Bird Treaty Act, and Lacey Act. Refuge officers also enforce the conservation provisions and restrictive covenants attached to federal wetland easements and Farmers Home Administration (FmHA) conservation easements which are spread across the Tamarac WMD. Conservation provisions primarily restrict agricultural use and development on easement lands. Enforcement operations are crucial to preserving these important natural resources situated in a broken and over developed landscape.