

Chapter 3



Lee Karney/USFWS

Great Blue Heron

Affected Environment

Landscape Setting

Champlain Valley Biophysical Region

The Missisquoi National Wildlife Refuge (Missisquoi Refuge, the refuge) lies on the eastern shore of Lake Champlain in the Champlain Valley biophysical region of northwestern Vermont (map 3-1). That biophysical region extends beyond Vermont north and east to the St. Lawrence River and west into New York to the Great Lakes (excluding the Adirondacks). It is relatively warm, dry, and low in elevation compared to the surrounding landscape; local Vermonters call it the “banana belt.” The mean summer temperature is 70°F; winter temperatures average 19°F. The annual precipitation in the Champlain Valley averages 28 inches close to the lake (Thompson and Sorenson 2000).

The refuge also lies within the Bird Conservation Region (BCR) 13, the Lower Great Lakes, St. Lawrence Plain and, more specifically, in the St. Lawrence Plain physiographic area (map 1-2) (Rosenberg 2000, Hartley et al. 2005). Because of agriculture, that is now the largest and most important area for grassland birds in the Northeast. The small riparian and deciduous forest habitat that remains in the St. Lawrence Plain supports several high priority birds, most notably a large, expanding population of cerulean warbler. Shrubland habitat is important for golden-winged warbler and American woodcock (Rosenberg 2000).

Missisquoi River Watershed and Missisquoi Bay

The refuge sits at the mouth (delta) of the 767,000-acre Missisquoi River watershed that drains portions of Quebec and Vermont. Each spring, its waters submerge large portions of the refuge. The 88-mile river flows through the refuge and then into Lake Champlain at Missisquoi Bay. The geography and water flow of Lake Champlain creates five easily identifiable segments with different physical characteristics and land uses in their respective sub-basins. Missisquoi Bay is in the northeastern corner with significant agriculture in the surrounding uplands. The bay is broad (5 to 10 miles across), shallow (maximum depth 15 feet), and warm. Some of the major management issues in the bay are seasonal blue-green algae blooms, high phosphorus levels, and a white perch invasion (Lake Champlain Steering Committee 2005).



Missisquoi Bay

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Lake Champlain

The Lake Champlain Special Designation Act (Public Law 101-596) designated the lake a resource of national significance in 1990. The Lake Champlain Basin Program (LCBP) was established to coordinate the activities the act envisioned: bringing together people with diverse interests in the lake to create a comprehensive pollution prevention, control, and restoration plan for protecting the future of the Lake Champlain Basin.

The seasonal pattern of flooding in the Lake Champlain Valley, together with annual variations in the overall level of Lake Champlain, stimulate and maintain the diversity and the dynamic vitality of the lakeshore and floodplain vegetation. Although water levels generally change according to a fairly predictable seasonal

pattern, variation in the level of Lake Champlain from year to year results in “low water” years and “high water” years. The distribution and density of emergent plants and the timing of their growth depend on that variation. The following graph from the National Weather Service depicts the range of variations in lake levels during the year.

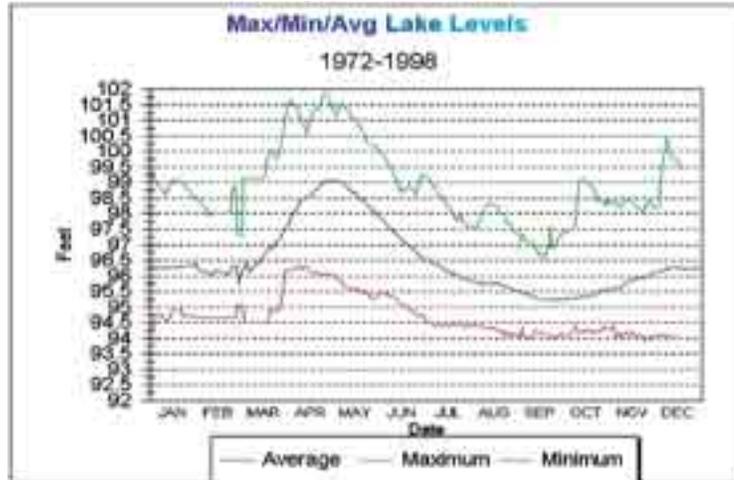


Figure 3.1. This National Weather Service graph depicts the range of variations in Lake Champlain water levels throughout the year. (<http://www.erh.noaa.gov/er/btv/lake/1972-1998avglakelevel.jpg>)

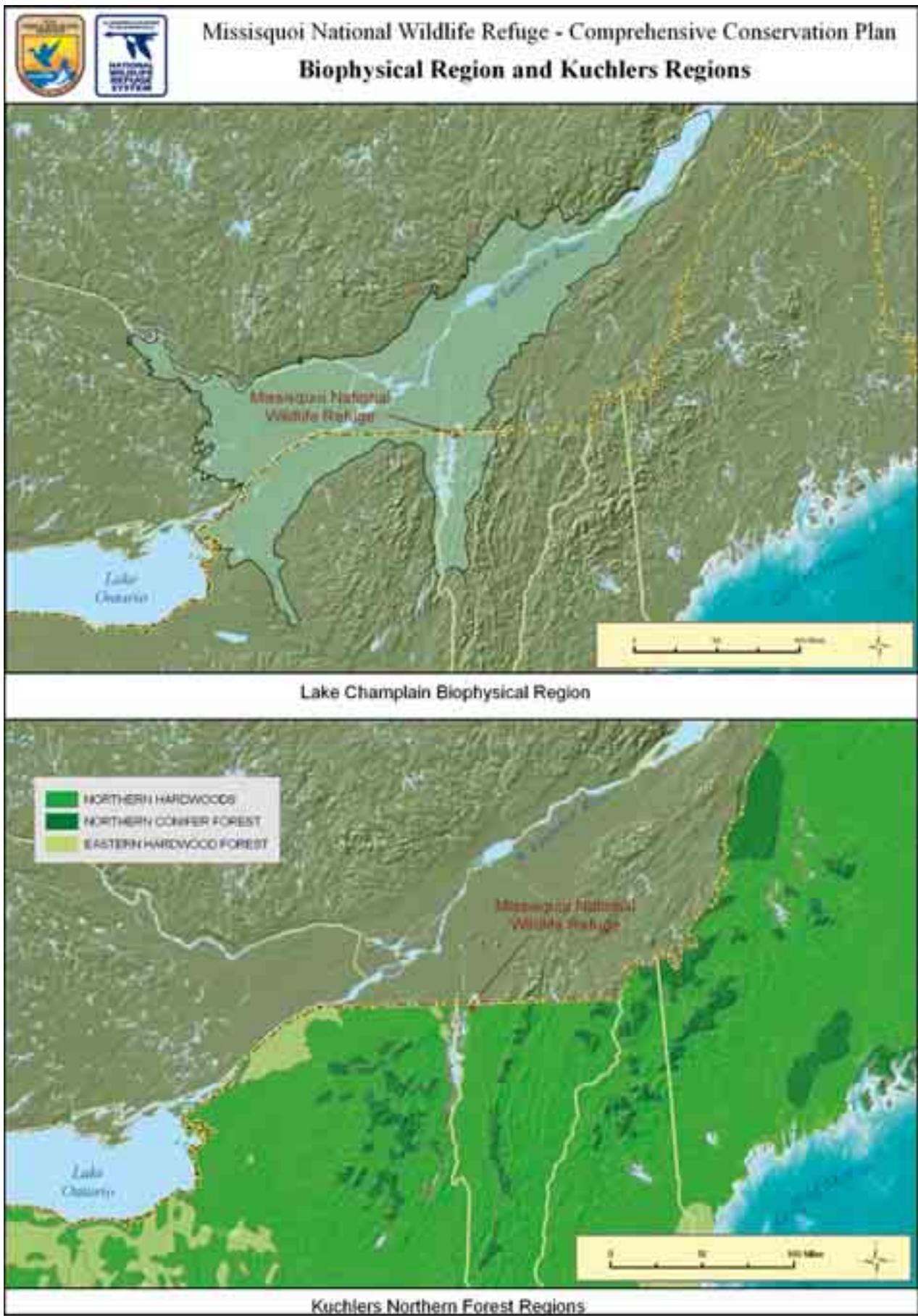
A peak lake level between 99 and 101 feet mean sea level (msl) is common in the spring, and high levels may remain until mid summer if spring or summer precipitation is above normal. The lake level usually recedes during the summer, and reaches its seasonal low of 94 to 95 feet msl between August and October.

The major management concerns for the lake are water quality, habitat degradation, and invasive exotic species. Lake Champlain is Vermont's largest body of water, which it shares with New York and Quebec. The many tributaries that feed the lake flow through vast areas of developed and agricultural lands that contribute polluted run-off to the rivers and, eventually, the lake. Several invasive aquatic species, including zebra mussel, water chestnut, and an exotic snail, are wreaking havoc on native fish and wildlife populations. Missisquoi Bay has been spared some of those species, although water chestnut was found on the refuge for the first time in 2005.

Missisquoi River Delta

Fillon (1970) described the uniqueness of the Missisquoi River Delta in the Lake Champlain Basin and its similarity to the Mississippi River Delta. The similarities are in the arrangement and small number (three) of the distributaries (creeks that branch off from the main stem before reaching the lake), and the presence of only a narrow strip of delta on either side of the river for a long distance upstream from the point of branching. These long, narrow deltas found at the mouth of the Missisquoi and the Mississippi Rivers are known as “bird’s foot deltas”

The geomorphology of the Missisquoi Delta is always changing. Precipitation (carrying and depositing sediments) in the Missisquoi River watershed and in Lake Champlain, and wind (creating wave action) in the Lake Champlain Valley affect the deposition and erosion of sediments in the delta. The period of



greatest sediment discharge, and therefore, of greatest delta-building activity is in April and May. Fillon (1970) compared the morphology of the 1970 delta to a depiction generated in 1857 (see Clews 2002). In that 100+ years, Shad Island had advanced more than one quarter of a mile out into the lake, the northwest corner of Hog Island and Martindale Point retreated, and Maquam Creek shifted from a navigable waterway to a smaller channel narrowed by sedimentation and natural building of levees. At various times in the past, Fillon (1970) concluded, based on evidence of former deltas in Maquam Bay and an abandoned channel along Maquam and Black Creeks that the Missisquoi River emptied into Maquam Bay. Fillon (1970) used aerial photos to identify relict channels and natural levees or terraces in the Missisquoi River Delta.



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Aerial view of Missisquoi River Delta

For the last 500 years or more, the main stem of the Missisquoi River has flowed north into Missisquoi Bay. Despite dam construction upstream, including one in Swanton that changed the flow rate and sediment loads, the delta continues to expand northward. The main channel is more stable now than during its long history; a result of the riprap along the river stretch that runs parallel to Route 78 and the 3 miles of dikes on the refuge (Clews 2002).

The hydrology of Maquam Bog, south of Route 78 and between the mainland and Hog Island, is also complex. The bog sits about 1 foot above the average lake level and, as a result, it is seasonally flooded, mostly from Charcoal Creek to the north. A natural terrace formed on the southern edge of the bog by wave-thrown sand from Maquam Bay. In the early 1900s, a railroad was built atop that terrace, creating an additional barrier to floodwaters from the bay.

More study is needed to understand how far floodwaters penetrate the bog or how much groundwater contributes to the bog's hydrology (Clews 2002).

Geology

Lake Champlain lies on a fault bounded between the Pre-Cambrian Adirondack Mountains of New York to the west and the Cambro-Ordovician Green Mountains of Vermont to the east. The bedrock on the eastern shore of Lake Champlain surrounding and under the Missisquoi River Delta consists of black shales of the Ordovician Iberville Formation. The bedrock of the eastern two-thirds of the Missisquoi River drainage is metamorphic consisting mainly of phyllites, schists, and graywackes. The western part of the drainage is sedimentary, mainly shales and dolomites (Fillon 1970). Due to the deep deposition of deltaic sediments, the bedrock of the lower Missisquoi River crops out in only a few areas, and thus, does not generally influence the distribution of plant and animal communities on the refuge (Clews 2002).

Water Quality

Three major tributary rivers—Missisquoi, Rock, and Pike—feed into Missisquoi Bay. The refuge manages a conservation easement in the Town of Highgate, where the Rock River enters the United States from Canada. The river then passes through a mix of privately owned and state-owned wetlands before it enters the bay. The Pike River enters Missisquoi Bay in Canada. The bay receives the highest phosphorus load of any section of Lake Champlain. Discharge from wastewater treatment plants and runoff from nonpoint sources, including lawns, farms, and urban areas, carry phosphorus into the waterways. More than 90 percent of the phosphorus entering the bay is from nonpoint sources (Lake Champlain Steering Committee 2005).

Phosphorus is not harmful to humans; however, high phosphorus levels cause algal blooms that degrade water quality for aquatic life, affect recreational

enjoyment and, if algal toxins are present, can irritate skin and cause internal damage to pets and humans. Nuisance algal blooms were first recognized as a problem in the mid-1990s when large blooms occurred in Missisquoi Bay. The toxin microcystin, produced during blue-green algae blooms, regularly exceeds recreational use guidelines in the bay from July to September (Lake Champlain Steering Committee 2005). The refuge is concerned about the impacts of the algal blooms on wildlife and wetlands habitats as well as recreational opportunities.

The LCBP has funded phosphorus and other water quality monitoring since 1992. From 1990 to 2004, Missisquoi Bay consistently failed to meet the standards set by the State of Vermont. In 2002, Vermont and New York developed a plan to reduce phosphorus loads carried to the lake by its tributary rivers. Also in 2002, Vermont and Quebec signed an agreement to allocate responsibility for phosphorus reduction in the Missisquoi sub-basin: 60 percent for Vermont; 40 percent for Quebec (VT DEC 2005c)

Additional water quality issues in Missisquoi Bay include the presence of mercury and pesticides and the spread of invasive species. Other water quality concerns on the refuge include increased sedimentation caused by upstream Missisquoi River watershed land uses that cause stream bank erosion or increased runoff. Extreme floods exacerbate that sedimentation. Throughout the year, but especially in the spring, the Missisquoi River carries loads of sediment into the refuge where the water spreads out through the floodplain, dropping the sediment into wetlands, fish spawning areas, and mussel beds.

Walleye come up from Lake Champlain into the lower Missisquoi as far as the Swanton dam. The State of Vermont Department of Health issued a fish consumption advisory for that 8-mile stretch due to mercury contamination from atmospheric deposition in the walleye. There are three permitted direct wastewater discharges, two indirect wastewater discharges, and at least seven permitted storm water discharges to the lower Missisquoi River and its tributaries. Along the length of the lower Missisquoi River, aquatic life and their habitats are stressed from high sediment loads, turbidity, nutrient enrichment, and temperature, and loss of riparian vegetation and stream bank erosion (VT DEC 2005b).

Air Quality

The Environmental Protection Agency (EPA) reports that Vermont meets National Ambient Air Quality Standards (NAAQS) of the Clean Air Act without exception (EPA 2005). The concentration of carbon monoxide is far below the lawful limit, as is that of nitrogen dioxide. The air quality of the refuge is thought to be very good. Vermont has the lowest recorded levels of ozone concentration of the six New England states and none of its monitoring sites exceeded the standards set by the EPA. Other air quality parameters that the monitoring site in Burlington, Vermont, measures include sulfur dioxide, carbon monoxide, nitrogen dioxide, particulate matter, and fine particulates (EPA 2005).

The Historical Picture

Glaciation

All of New England and northeastern New York were affected by the last continental glaciation, the Wisconsin, which peaked about 18,000 years ago. As the ice sheet began receding, its melt waters were blocked from draining northward by the ice, allowing historical Lake Vermont to form in the Champlain Valley. By 11,000 years ago, the glacier had receded beyond the St. Lawrence lowlands, allowing water from the Atlantic Ocean to reach the Champlain Valley. That marine embayment was called the Champlain Sea. As the glacier continued to regress northward, the weight of the ice sheet lifted, allowing the Earth's crust to rebound and lift the northern rim of the Champlain Valley above sea level, forming a barrier to the ocean. That initiated a gradual transition from a

saltwater, to a brackish, to a freshwater aquatic environment that was complete by about 8,000 years ago (Chapman 1937). As the sea receded, thick deposits of clay, and in some places sand, remained to form some of the best farmland in eastern Canada and northeastern United States. Flying over northern Vermont today, one sees the Green and Taconic Mountains flatten and separate into the vast Champlain Valley, site of ancient seas. Immediately to the north, in Canada, the land broadens still farther into the valley of the St. Lawrence.

As the great continental ice sheets melted, they left behind river deltas and sand-gravel margins, creating a medium for the growth of a distinctive mosaic of plants found in few other places in northern New England. Before European settlement, the region was dominated by silver maple floodplain forest, red-maple black-ash swamp, mesic oak hardwood forest, and sugar maple-beech-birch forest, depending on site-specific conditions. Pitch pine-scrub oak woodlands, emergent freshwater marshes, and large river systems were embedded in the region. Little of that natural vegetation remains in the St. Lawrence Plain, based partly on natural changes, but mostly because of large-scale, human-induced disturbance (Rosenberg 2000). The Missisquoi Refuge hosts some of the best remaining examples of those habitats.

Human History

Early History

The exploration and exploitation of the Champlain Lowlands may have begun as early as 7500 B.C. Upstream on the Missisquoi River, on sandy beach deposits of the former Champlain Sea in Highgate, the Reagan Site was occupied by late Paleo-Indian times, 10,000 to 9,000 years ago. The site overlooked the Champlain Basin from an elevation of 500 feet (Thomas and Robinson 1979.) However, there are no known Paleo-Indian Period sites on the refuge. Although the Missisquoi Delta was exposed at that time, it still may have been too wet to be attractive for living (Thomas and Robinson 1979).

The Early Archaic Period (9,000 to 7,500 years ago) at Missisquoi coincides with a shift in environment to more closed forest cover (Corey et al. 2002:13). Both Early Archaic and Middle Archaic people seem to have used a wide variety of environments (Thomas and Robinson 1979). On the Missisquoi River in Swanton, upstream from the refuge, an Early Archaic site on a high terrace of the Missisquoi yielded corner-notched projectile points and a suite of stone tools dating to 8,100 years ago (Thomas and Robinson 1979). Two other Early Archaic sites have been dated in Highgate (Thomas and Robinson 1979), but no sites with Early Archaic tool kits or dating to that period have been found on the refuge. Delta buildup after the Early Archaic Period is likely to have buried any evidence of that period on the refuge (Hight and Wilson 1997). Small group size and low regional population during the Early and Middle Archaic may mean that their archaeological sites generally are smaller and easier to miss (Thomas and Robinson 1979).

Recent archaeological work just off the refuge revealed a Middle Archaic Period archaeological site (Ellen R. Cowie, pers. Comm., 2005). It is likely that Middle Archaic people also used the refuge land. Elsewhere in New England, Middle Archaic people gathered at resource-rich sites to fish, work wood, and knap stone tools from stone obtained in the same drainage (Dincauze 1976).

According to Thomas and Robinson (1979) the Late Archaic Period (6,000 to 3,000 years ago) is widely represented in Vermont, although not many sites of that age are known in the Missisquoi River drainage. Late Archaic artifacts form a large percentage of surface collections in western Vermont. A large number of Late Archaic projectile points have a wide distribution in the Champlain

Basin, and islands in the wet basin or wet environments in general attracted Late Archaic people in other parts of Vermont. The use of steatite bowls and the introduction of ceramic pots at the end of the period are significant.

The Early Woodland Period (3,000 to 2,100 years ago) is represented by archaeological sites on the refuge as well as upstream. Some artifact continuity from the Late Archaic to the Early Woodland represents continuity of the basic subsistence and settlement patterns during those two periods. Hunting, fishing and gathering are not markedly different from the Archaic Period. Heightened burial ceremony and elaborate grave goods characterize that period in the Missisquoi Valley as well as other rivers in New England (Thomas and Robinson 1979). Early Woodland habitation sites have been identified on the refuge.

The Middle Woodland Period (2,100 to 1,000 years ago) (Corey et al. 2002) is marked by a continuation of hunting, fishing and gathering activity, and evidence of larger groups and perhaps more frequent visits to the same sites (Thomas and Robinson 1979). Nut and fish storage pits and perhaps corn horticulture existed by the end of this period. The presence of large, heavily used Middle Woodland sites have been discovered in the lower Winooski, Lamoille and Missisquoi intervales before those rivers enter Lake Champlain (Thomas and Robinson 1979) and in the Connecticut River Valley in Vermont.

The late Woodland Period (A.D. 1000–1650) (Corey et al. 2002) is characterized by a continuation of subsistence hunting, fishing, and gathering, but corn (grown in the Connecticut River Valley by A.D. 1100), bean and squash horticulture became increasingly important. Larger communities began to develop as storable foods and palisaded sites began to be constructed in river valleys by about A.D. 1350 (Thomas and Robinson 1979).

Historical Land Use

Because large Late Woodland villages are known along the lower intervals of the Winooski, Lamoille and Missisquoi rivers, and there is no evidence of displacement, the ancestors of the Western Abenaki Nation of Missisquoi who inhabited the region in the seventeenth and eighteenth centuries probably used the Champlain lowland well before the seventeenth century. By the end of the 1600s, the French had established a mission at Missisquoi. A clearer picture of the Indian community at Missisquoi emerges from eighteenth century records. The war chief Grey Lock is prominent in those events (Thomas and Robinson 1979). Grey Lock raided English settlements along the Connecticut River in Massachusetts from 1723 to 1727 (Calloway 1990). He continued to live at Missisquoi at least until 1744 (Calloway 1990).

The Jesuits built a mission church on the Missisquoi River in about 1741. During the French and Indian War (1754–1763), much of the Missisquoi community withdrew to Quebec. With the end of the French and Indian war, returning Missisquoi families encountered English settlers moving into lands along the Missisquoi River and Lake Champlain (Thomas and Robinson 1979).

English settlement began to expand in the mid-to-late 1700s. James Robinson leased a large tract of land from the Indian community in 1765, and built a sawmill at the Swanton Falls, on the site of a previous French mill. Thomas Metcalfe built a trading post on Shad Island at about that time as well. European settlements continued to grow, and the Allen family facilitated settlement by settlers holding their titles from New Hampshire and Vermont (Thomas and Robinson 1979). One refuge tract title chain goes back to Heman Allan, one of Ethan and Ira Allan's brothers.

The Town of Swanton held its first town meeting in 1790. Approximately 800 white settlers resided in Swanton by 1800. It grew considerably during the nineteenth century, expanding from a population of 74 in 1791 to 3,079 in 1880. Sawmills, gristmills, tanneries, marble works, and potash production developed in the Swanton area from the mid-1800s until the early 1900s.

Socioeconomic Environment

Population Demographics

The U.S. Census Bureau Vermont State Data Center is housed at the University of Vermont (UVM) Center for Rural Studies. The website (<http://crs.uvm.edu/census/>) has data on populations in Vermont communities. Table 3.1 displays a subset of that information.

Table 3.1. Population changes from 2000 to 2004 in Vermont, Franklin County, and the Towns of Swanton and Highgate*

	2000 Population	2004 Population	% Change
State of Vermont	609,941	621,394	1.9
Franklin County	45,599	47,556	4.3
Town of Swanton	6,223	6,423	3.2
Town of Highgate	3,423	3,628	6.0

*Vermont State Data Center, 2005

Economics of Franklin County

The economy of Franklin County is based on a mix of agriculture, tourism and recreation, and industry. Many businesses near Lake Champlain cater to recreational interests and tourists. Campgrounds, fishing and other sporting goods and services, motels, and bed and breakfasts abound in the area. In addition, both Swanton and St. Albans have industrial parks that are slowly but steadily growing.

Farming is one of the largest land uses in the county. In 1997, 47 percent of the county, or 190,215 acres, was in farms. Franklin County is the largest dairy producer in Vermont and in New England. Dairy farms generated more than 75 percent of the total agricultural sales for the County. The total economic impact of the agricultural industry in Franklin County is estimated at more than \$210 million, providing more than 10 percent of all the jobs in the region (American Farmland Trust 2002).

In 1987, Vermont enacted the Farmland Conservation Program to permanently protect land for agriculture. Vermont consistently invests more money per capita on farmland conservation than any other state in the U.S. By 2002, this program had helped protect 25,000 acres in Franklin County. Between 1982 and 1997, 15 percent of the farmland in Franklin County was lost to development; lower than the 20 percent statewide average (American Farmland Trust 2002). Many people who live near the refuge commute to jobs in the Burlington area. The relatively high cost and low availability of housing in the neighboring counties, especially Chittenden County that encompasses Burlington, is causing an increase in residential development pressure in Franklin County.

Farmers have sold the development rights to their farmlands to land trusts to provide cash for farm improvements, to buy more land, for retirement, and to

ensure that the land will be there for their children to farm in the future. Of the 41,408 total acres in the Town of Swanton, about 13,000 acres, or 31 percent, are conserved. Federal and state wildlife refuges encompass about 7,000 acres of that total and the rest lies in the form of conservation easements on private lands. Twenty-seven privately owned dairy farms, representing roughly half the dairy farms in Swanton, are conserved. Swanton has the highest percentage of conserved land of any community in Vermont; its boundaries encompass roughly 16 percent of all the conserved land in the state (Vermont Land Trust, unpublished data, 2000). Map 1-3 depicts the distribution of conserved lands throughout Franklin County.

Refuge Administration

Establishment

Missisquoi Refuge was officially established on February 4, 1943 “...for use as an inviolate sanctuary, or any other management purposes, for migratory birds” under the Migratory Bird Conservation Act. Today, the refuge encompasses 6,570 acres of the Missisquoi River delta. Only 8 few parcels, totaling 253 acres, remain within the approved acquisition boundary to acquire (map 1-3).

The refuge also owns a 262-acre parcel in Westville, New York about 10.5 miles north of the City of Malone, along the Canada-U.S. border (Map 3-2). This parcel was acquired under provisions of the 1985 Farm Bill. Most of the Westville Unit is reverting agricultural land. The Westville Unit is open to the public, however there are no developed facilities such as walking trails, observation areas, and access points. The refuge holds a conservation easement on a 71-acre Rock River parcel in Highgate (Map 3-3) as well as easements on several other properties. These easements were granted to the US Fish and Wildlife Service (USFWS) through the Farmers Home Administration debt-restructuring program for farmers. The program allows for reduction of borrower debt in exchange for permanent conservation easements on valuable habitat, including wetlands.

Land Acquisition

The land acquisition program at Missisquoi in the recent past has been both opportunistic and, at the same time, measured. There are several parcels within the approved Refuge boundary that the Service will try to acquire if the owners indicate an interest and willingness to sell. Likewise, there are many parcels outside, but adjacent to, the approved boundary that would be eagerly considered were the landowner to indicate an interest to sell. Since 2000, the Mudgett Island inholding became available for a short time, but ultimately ownership was retained within the family. No other in-holdings have been nor are currently available for consideration by the Service.

Also since 2000, several parcels were added to the perimeter of the refuge; one a 93-acre parcel on the southern boundary of the refuge known as the Hawley Tract and the other a 39-acre parcel on the southwest corner known as the Lussier tract.

Additionally several attempts were made to purchase lands in four parcels from two landowners near Tabor Road either adjacent to or nearly adjacent to the southwest refuge boundary. Those attempts were not successful largely due to a hot real estate market; the parcels have since been sold to other parties with two being developed for single-family housing. A third parcel was an active dairy farm and remains so under new ownership by a family member of the original owner. The last parcel was an active dairy farm and remains so under the original owner. In all cases the landowners wished to sell to the refuge and approached the refuge with the proposal, but we could not reach mutually agreement on property values.

The Service has worked to acquire three 10-acre parcels adjacent to the Monument Road in Highgate. These parcels, although not adjacent to the refuge boundary are within ¼ mile. The refuge manager has worked for several years with U.S. Senator Patrick Leahy's office and a multi-partner working group to protect culturally sensitive lands in this vicinity. These three parcels not only are culturally sensitive, they harbor important wildlife and habitat values. Addition of these parcels to the refuge is imminent.

Through the Migratory Bird Commission, the Service acquired another 10-acre parcel adjacent to the refuge boundary at the Stephen J. Young Marsh in the southwest portion of the refuge along Tabor Road.

Other areas that are of interest to the Service for addition to the refuge include: the forested and emergent wetland between the existing Refuge boundary along Dead Creek and Burton's Pothole, and the three 10-acre parcels being acquired along Monument Road; the emergent marsh adjacent to the refuge boundary near the mouth of Dead Creek in Missisquoi Bay; the tract of land bordering the refuge west of Charcoal Creek south of Route 78; additional wetlands and meadows along Tabor Road; and any of the five in-holdings (Coleman at Charcoal Creek, Hilliker's Pothole, Comolli's Marsh, Mudgett Island, and Bruyette's Islands).

Also of interest to the Service would be discussions with the Vermont Fish and Wildlife Department (VT FWD) to determine the feasibility and advantage of nearby or bordering State lands being transferred to the Service or managed by the Service as part of the Missisquoi National Wildlife Refuge or vice versa. Lands that could be part of that discussion would include: the abandoned railroad bed trail through the refuge from Tabor Road southeast to the shore of Lake Champlain at Maquam Bay; portions of the Maquam Bay Wildlife Management Area (WMA); the Carmen Marsh and old Fish Hatchery parcel near Sandy Point; the Service conservation easements near the Rock River in Highgate. Opportunities could be explored for land exchange or joint management agreements that would facilitate overall management of the area for both agencies.

Staffing and Budgets

The current Refuge staff includes:

- Refuge manager (GS-13)
- Refuge operations specialist (GS-11)
- Administrative support assistant (GS-6)
- Park ranger (GS-11)
- Maintenance mechanic (WG-9)
- Student Career Experience Program (SCEP) student (GS-4)
- Wildlife Biologist (GS-11)

Three additional positions are approved but unfilled—that of a park ranger (GS-9) and a maintenance worker (GS-5). The wildlife biologist (GS-11) retired in January 2006. See the organization chart in Appendix H.

Annual budget appropriations vary from year to year, depending on the Service's overall budget and how the refuge's needs and requests rank regionally and nationally with other Refuges. Table 3.2 summarizes budget levels from 1998 to 2004. Funding fluctuations reflect dollars earmarked for special projects. For example, 1998 maintenance funding included the replacement an aged Refuge vehicle. In 2000 the refuge received additional funding for the replacement



of an aged dump truck, pickup truck and two Jon boats. In 2001, additional allocations in maintenance funding covered a major dike rehabilitation project estimated at \$347,000 and a Youth Conservation Corps (YCC) crew. The refuge received additional funding in 2002 for ecosystem cooperative projects in station operations funds and funding for another YCC crew along with a new radio system in maintenance funds. The notable increase in operations and maintenance spending in 2004 is due to the expense of constructing a new Refuge Headquarters and Visitor Contact Station.

Table 3.2. Refuge budgets from 1998 to 2004.

Fiscal Year	Operations	Maintenance	Total
1998	\$255,200	\$50,000	\$305,200
1999	\$315,100	\$20,000	\$335,100
2000	\$374,900	\$146,000	\$520,900
2001	\$381,200	\$391,000	\$772,200
2002	\$425,200	\$70,500	\$495,700
2003	\$419,616	\$126,992	\$546,608
2004	\$652,157	\$567,900	\$1,220,057

Facilities and Maintenance

Missisquoi Refuge facilities currently include the new Refuge Headquarters and Visitor Contact Station, a storage building, a service building, two cold storage buildings, an equipment shed, an oil shed, above ground fuel tanks with covers, three comfort stations, a loading dock, and two travel trailers located at Refuge Headquarters for use by researchers. In addition, a new maintenance compound is currently under construction. The maintenance staff is responsible for the upkeep of all these facilities.

The refuge also maintains two kiosks, four gravel parking lots, a mile-long gravel road, three boat ramps, and a handicap accessible fishing bulkhead and concrete parking area. Maintenance personnel are also responsible for boardwalks, sidewalks, nature trails, fencing, informational and interpretational signs, wood duck and bluebird boxes, boundary signs, a radio tower, a flag pole, and the headquarters lawn and septic system. Maintaining gravel parking lots and roads often requires much time and effort, especially after spring flooding. Yearly boundary sign checks are done in the winter when access and maneuverability over the ice is much easier.



Refuge Headquarters and Visitor Contact Station

© James A. Coan, AIA of Centerbrook Architects

The refuge manages three water impoundments in the Missisquoi Delta: Cranberry Pool, Goose Bay Pool, and Big Marsh Slough. These impoundments are encompassed by three different dike systems, one with an operating water control structure. A second water control structure is in the 2-acre Stephen J. Young marsh, and is manipulated to control water levels. Also on the delta are two of the refuge’s storage buildings. Maintaining these dikes, impoundments, and buildings offers added challenges to maintenance staff; all equipment must be moved to

the island by barge, which complicates even the smallest maintenance tasks. The barge and barge slip bulkhead in turn must be maintained.

Table 3.3. Refuge Roads and Infrastructures

	Size	Year Built	Alternative A	Alternative B
Levees, Dikes, Water Control Structures, Bulkheads				
Barge Slip	150 lin ft	1978	Maintain	Same as A
Bulkhead Mac's Bend	44 lin ft	1978	Maintain	Same as A
Big Marsh Slough dike	300 lin ft	1958	Maintain	See Goose Bay dike
Goose Bay Pool dike	1,500 lin ft	1959	Maintain	Evaluate potential of extending dike approx ½ mile through Big Marsh Slough
Cranberry Pool dike	15,840 lin ft	1968	Maintain	Same as A
Cranberry Pool water control structures	2	1968	Maintain	Same as A
Sheet piling at Cranberry Pool water control structures	160 lin ft	1986	Maintain	Same as A
Handicapped accessible fishing bulkhead at Louie's Landing	48 lin ft	1997	Maintain	Same as A
Stephen J. Young Marsh dike and water control structure	200 lin ft	1995	Maintain	Same as A
Boat Launch Areas				
Launch #1 at Mac's Bend	40 ft x 10 ft		Maintain	Same as A
Launch #2 at Mac's Bend	40 ft x 10 ft		Maintain	Same as A
Launch at Louie's Landing	60 ft x 20 ft	1966	Maintain	Same as A
Canoe/kayak boat launch		This would be new	----	Create along Missisquoi River as part of Rt 78 realignment
Roads and Parking Areas				
Mac's Bend Road, gravel	1 mile	1953	Maintain	Same as A
Mac's Bend parking lot	10,000 sq ft	1979	Maintain	Same as A
Louie's Landing parking lot	21,900 sq ft	1979	Maintain	Same as A
Jeep Trail, 1 lane, earth base	3 miles	1983	Maintain	Same as A
Old Headquarters parking lot	15,000 sq ft	1959	Maintain	Same as A
New Headquarters/Visitor Contact Station's parking lot	48,000 sq ft	2005	Maintain	Same as A
Public use parking areas (2 on Tabor Road)	5,000 sq ft each	1970	Maintain	Same as A

	Size	Year Built	Alternative A	Alternative B
Roads and Parking Areas (cont'd)				
Handicapped accessible concrete parking area, Louie's Landing	700 sq ft	1997	Maintain	Same as A
Buildings				
New Headquarters/Visitor Contact Station	7,250 sq ft	2005	Maintain	Expand Visitor Contact Station hours, including weekends
New Maintenance Building	7,000 sq ft	2006	Maintain	Same as A
Storage shed, old gas shed	64 sq ft	1950	Demolish	Same as A
Storage building (Mac's Bend)	1,500 sq ft	1958	Maintain	Same as A
Former milk house, 96 sq. ft. (1968)	96 sq ft	1968	Demolish	Same as A
Old Headquarters building	2,530 sq ft	1958	Salvage	Same as A
Oil shed	320 sq ft	1959	Demolish & Replace	Same as A
Cranberry Pool dike open storage building	625 sq ft	1968	Maintain	Same as A
YCC Service Building	1,600 sq ft	1978	Salvage	Same as A
Restroom Facility (nature trail)	36 sq ft	1996	Maintain	Same as A
Restroom at Mac's Bend	64 sq ft	1997	Maintain	Same as A
Restroom at Louie's Landing	128 sq ft	1997	Install locks with timers; consider moving if problems persist	Same as A
Pre-Fab Metal Flammable Materials Storage Building	123 sq ft	2005	Maintain	Same as A
Cold storage building at Cranberry Pool dike	900 sq ft	1999	Maintain	Same as A
Trails and Boardwalks				
Black and Maquam Creek Trail	1.75 mile	1963	Maintain	Add elevated boardwalk
Mac's Bend Trail	1 mile	1943	Maintain vehicle access from Sept to Dec	Expand vehicle & bicycle access from April to Dec; install an electronic gate
Jeep Trail	2.5 miles	1943	Maintain	Enhance signage and gate to ensure pedestrian traffic only; Shorten trail to where river branches, install a bench
Discovery Trail	1 mile	2005	Complete in 2006; add handicapped access	Same as A

	Size	Year Built	Alternative A	Alternative B
Trails and Boardwalks (cont'd)				
Stephen J. Young Marsh Trail	1.25 miles	2004	Complete in 2006 with YCC	Same as A
Old Railroad Passage Trail	1.5 miles	2002	Maintain	Construct boardwalk to reach Maquam Bay and to a Maquam Bog overlook; add interpretive signs and blind at each
Outdoor Classroom	40		Within 5 years	Same as A
Information Kiosks				
Black and Maquam Creek Trailhead		1987	Maintain	Same as A
Louie's Landing		1990	Maintain	Same as A
New Headquarters/Visitor Contact Station		2005	Maintain	Same as A
Old Railroad Passage	----	----	----	Install within 5 years
Other				
Wind Turbine	80' Tower, 10 kW Turbine with 22' diameter rotor	2006	Maintain	Same as A
Refuge Boundary (clear vegetation and place signs)	200 signs/23.5 miles	1943	Annually evaluate signs along 8 miles of boundary	Annually evaluate signs along 12 miles of boundary
Wood duck boxes	130 boxes	1943	Maintain	Shift to natural cavities; don't replace old boxes, evaluate others for removal
Waterfowl hunting blind sites	23	1985	Maintain	Add 2 within 5 years
Osprey nesting sites	32	2005	Maintain	Evaluate and maintain as needed

Wind Turbine

The refuge completed the installation of a 10-kilowatt wind turbine in 2006 at its new headquarters complex to produce electricity for its facilities and to demonstrate and promote renewable energy production. The wind power generation complements other renewable energy features of the new headquarters/Visitor Contact Station that include 4.3 kilowatt generating capacity photovoltaic panels and a geothermal cooling system. Other conservation measures used in construction included environmentally friendly materials, recycled content materials, construction waste recycling, energy and water conservation, and site restoration.

The single wind turbine erected at Missisquoi Refuge is 80 feet tall with a rotor diameter of 22 feet. No guy wires are required. The wind turbine, combined with the photovoltaic array, provides power to the headquarters complex, reduces refuge operating costs, and in accordance with a Certificate of Public Good from the Vermont Public Service Board, is connected to the utility grid to allow net metering or sale of excess power to the local utility supplier. An interpretive

display in the new visitor's center will show the amount of electricity being produced by the turbine, the amount of electricity being used by the facility and highlight the technology and operation of the wind turbine, photovoltaic cells, and geothermal building features.



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Wind Turbine

Contributions of the Refuge to the Local Economy

The contribution of the Missisquoi Refuge to the local economy is multi-faceted. The refuge contributes directly to the local economy through shared revenue payments. The Federal government does not pay property tax on refuge lands; instead it makes annual payments to respective municipalities based on a maximum of 0.75 percent of the fair market value of refuge lands as determined by an appraisal every five years. The actual amount distributed each year varies based on Congressional appropriations, land acquisition, and the annual sale of refuge goods and products that contribute directly to the revenue sharing account. The latter includes proceeds from the sale of hay, timber products, etc.

Table 3.4. Annual refuge revenue sharing payments from 2000 to 2004.

	2000	2001	2002	2003	2004	Totals
Highgate	\$2,689	\$2,744	\$2,820	\$2,464	\$2,464	\$13,181
Swanton	\$5,271	\$5,380	\$3,702	\$4,912	\$4,912	\$24,177
Yearly Totals	\$7,960	\$8,124	\$6,522	\$7,376	\$7,376	\$37,358

The refuge also contributes indirectly to the local economy, yet provides valuable recreational opportunities for local residents and brings tourists and travelers into the area for the same reason. Public ownerships require little in the way of services from municipalities, yet provide valuable recreational opportunities for local residents. A 2001 national survey of hunting, fishing, and wildlife watching showed that 569,000 Vermont residents and nonresidents 16 years old and older fished, hunted, or watched wildlife in Vermont, and spent \$386 million on these activities. This included 171,000 anglers, 100,000 hunters, and 496,000 wildlife-watchers (USFWS & US Census Bureau 2003). Vermont ranked first in the nation in percentage of residents that actively observed wildlife (60 percent). At least 280,000 Vermont residents participated in wildlife-associated recreational activities; constituting nearly 50 percent of the state's resident population – the highest percentage in the nation. These statistics represent a significant contribution to Vermont's economy and highlight the strong connection Vermont residents and non-residents have to the land and wildlife (Kart et al. 2005).

Missisquoi Refuge is one of the premier spots in the State where these outdoor wildlife enthusiasts spend time and money. The refuge is popular for fishing, upland and big game hunting, and waterfowl hunting. The refuge is well known in Vermont as a premier waterfowl hunting venue. Each year, approximately 66 permits are sold to duck hunters at \$10 each. Waterfowl hunters contribute to the local economy through the purchase of gas, food, hunting-related equipment and clothing, boating gear, equipment repair services, and lodging.

Approximately 100 permits to hunt big game and upland game are sold annually on the refuge. Most hunters pursue white tailed deer, but a few hunt for other

species such as ruffed grouse, woodcock, or snipe. Although many hunters are local residents, approximately 20 percent reside outside Franklin County. These hunters contribute to local commerce through the purchase of gas, food, hunting-related equipment and clothing, and lodging.

Trapping is a small factor in the local economic picture. Trapping is conducted on the refuge on a very limited basis; in any given year only two or three parties trap. Trapping is focused on those animals that are causing infrastructure or management problems relative to waterfowl management activities. Raccoons are trapped in an effort to reduce their predatory impact on colonial nesting birds such as great blue herons and black terns, as well as their impact on nesting waterfowl. Trappers are usually local people who purchase food, gas and other supplies as they conduct their work. The pelts are usually sold to large fur houses and their profits directly benefit the trappers.

Other economic uses of the refuge include commercial minnow collecting and haying. About one half dozen bait dealers buy special use permits from the refuge each year to access the river via Refuge land and collect minnows for sale as fish bait to ice fishermen. The sale of the minnows supports both the bait dealers and those who engage in the popular pastime of ice fishing.

In an effort to economically maintain about 200 acres of grassland as grassy herbaceous habitat for migratory birds and other animals, the refuge has cooperative farming agreements with about half a dozen local dairy farmers. The farmers pay the refuge a small amount to harvest hay from refuge land each year.



USFWS

Raccoon

Increasing numbers of birdwatchers, photographers, naturalists, and boaters are drawn to the refuge. Recently the refuge was recognized as a premier stop on the Lake Champlain Birding Trail, likely leading to increased visitation, and, consequently, expenditure of funds in support of the local economy. In the next few years more canoeists are expected along the Northern Forest Canoe Trail, which courses from Maine to New York, passing through the refuge on the Missisquoi River. Increased visitation to the refuge is considered by many to be the cornerstone of the Swanton revitalization effort, as refuge users contribute to the local economy through consumption of goods and services, rental of equipment locally, and payment of fees for the use of shuttles and guide services.

The refuge manager and other staff have also been involved in the Route 78 Improvement Project, aiding in the planning effort to improve the portion of Route 78 from the downtown Swanton bridge to the West Swanton bridge.

Finally, the Missisquoi Refuge budget provides approximately \$400,000 per year to the local economy through staff salaries, expenditures for construction contracts on the refuge, and purchases from local businesses for operation and maintenance of the refuge.

Research

Several research thesis projects, studies, and investigations have been conducted on the refuge. A selection of these projects are listed below.

Biological Studies

- **From floodplain forest to pitch pine woodland bog: a landscape inventory and analysis of the Missisquoi National Wildlife Refuge, Swanton, Vermont.** 2002. Charlotte Clews. Field project for Master of Science, UVM.

- **A study of the response of eastern spiny softshell turtle to boat traffic in the Missisquoi River of Northern Vermont.** 2001. W. Max Meyer, U.S. Fish and Wildlife Service.
- **An assessment of breeding great blue herons (*Ardea herodias*) and the impact of double-crested cormorants (*Phalacrocorax auritus*) in the Shad Island Rookery, Swanton, VT.** 2001. Zoe Richards and David Capen, UVM. Paper prepared to the Lake Champlain Ecosystem Team.
- **The freshwater mussels of the Lower Missisquoi River: current status and the potential for a refugium from zebra mussel impacts.** 1999. Paul Marangelo. Vermont Agency of Natural Resources Technical Report.
- **Grassland bird breeding use of managed grasslands on National Wildlife Refuges within Region 5 of the U.S.** Fish and Wildlife Service. 2004. Michael C. Runge, Laura R. Mitchell, and Christopher J. Norment. Preliminary report to the National Wildlife Refuge System and Natural Resource Conservation Service.
- **Investigation of abnormalities in frogs on Region 5 National Wildlife Refuges: 2004 year-end report.** Pinkney et al. 2005. U.S. Fish and Wildlife Service.

Wildlife Monitoring and Surveys

The refuge conducts many biological surveys of wildlife each year, some in coordination with State partners. Annual productivity surveys are conducted on the following species or species groups:

- Great blue heron
- Osprey
- Waterfowl
- Black tern



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Management of Swim-in Traps

Surveys to assess habitat use and status of populations on the refuge include:

- Breeding marsh and wading birds
- Breeding land birds
- Grassland nesting birds
- Breeding frogs and toads
- Migrating waterfowl
- Furbearers
- Purple loosestrife
- Impoundment vegetation

Waterfowl Banding

Each fall the refuge staff, in collaboration with the State of Vermont, band an average of 200 to 300 ducks on the refuge. This effort supports the State's contribution to the Atlantic Flyway Council's banding program that helps guides waterfowl management decisions in the Flyway.

Monitoring Avian Productivity and Survivorship (MAPS)

Vermont Audubon established a MAPS station in the marsh, shrubland and forest surrounding the Steven J. Young marsh in 2001. MAPS is a cooperative effort among public agencies, private organizations, and bird banders in North America to provide long-term data on population and demographic parameters for more than 100 target landbird species at multiple spatial scales. The program uses

standardized, constant-effort mist netting and banding during the breeding season. The MAPS methodology provides annual indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured; and annual estimates of adult survivorship, adult population size, proportion of resident individuals in the adult population, recruitment into the adult population, and population growth rate from mark-recapture data on adult birds.

MAPS requires the standardized operation of a series of about 10 nets at permanent sites on one day during each of 6 to 10 consecutive 10-day periods between May and August. Standardization from year to year and continuation of the study for at least five consecutive years at each station are necessary to provide reliable productivity indices and survivorship estimates. Continuation of the study for 10 to 20 consecutive years at most stations will likely be necessary to obtain reliable trend information. One of the outcomes from the analysis of MAPS data by the Institute of Bird Populations is to identify those habitat characteristics associated with low productivity and those associated with higher productivity and in turn guide management that can lead to higher productivity (DeSante et al. 2005). Missisquoi Refuge has data for 2001-2004.

Cultural and Archaeological Studies

- **Archaeological phase I survey and archaeological phase II testing of the shift/off alignment and the on-alignment portions of the Vermont Route 78 Swanton Project NH 036-1(9), Swanton, Franklin County, Vermont.** 2002. Corey, R. P., E. C. Kitson, S. R. Scharoun, J. A. Reed, R. N. Bartone, and E. R. Cowie. Archaeological Research Center, Department of Social Sciences and Business, University of Maine, Farmington, Maine. Prepared for the Vermont Agency of Transportation.
- **Missisquoi National Wildlife Refuge: a cultural resource survey.** 1979. Peter A. Thomas and Brian Robinson. Report submitted to the Interagency Archeological Services, Atlanta, Georgia, by the Department of Anthropology, UVM, Burlington, Vermont.

Wildlife and Habitat Management

The focus of habitat management on the Missisquoi Refuge is to maintain and enhance habitat for migratory birds. Table 3.5 lists the management tools we use annually on the refuge to achieve habitat objectives.

Table 3.5. Current habitat management on the refuge.

Management Action	Area Treated	Objective of Action	Measurements
Prescribed burning	20 to 100 acres	Maintain herbaceous cover on old fields and improve nesting conditions for migratory birds	Observations Vegetation transects
Haying	184 acres	Maintain grassland bird nesting habitat	Point count survey
Hydroaxing in early successional habitat	20 acres	Create different age classes of early successional hardwoods for woodcock and other species	Observations MAPS data
Manipulating water levels	2 acres (Stephen J. Young Marsh) 550 acres (Cranberry Pool)	To maintain high-quality wetland habitat for breeding, foraging, and migrating waterfowl, water birds, and other marsh birds	Water levels at the control structure; waterfowl, marsh and waterbird surveys
Trapping	200 animals	Manage populations of muskrats, beaver, and raccoon to reduce damage to dikes and other structures and prevent predation on waterfowl and water birds	Muskrat and beaver house counts Weekly trapper harvest data

Cooperative Agreements

Cooperative agreements are legal contracts between a refuge and an educational facility or agency that specializes in an area of research applicable to that refuge. They allow the parties to share resources, funding, and research results as specified in the agreement. The Missisquoi Refuge now has several cooperative agreements in place to support refuge research: two of them with UVM. The first of those regards continuing research on the Shad Island great blue heron rookery and the impact that the double crested cormorant may impose on the rookery. The second provides for the development of a digital database of land cover and land use for riparian areas in the Lake Champlain Basin. When completed, that database will be shared with members of the Lake Champlain Ecosystem Team and other interested agencies, with the goal of achieving the future conservation and restoration of riparian habitat within this basin. The refuge also has a cooperative agreement in place with Audubon Vermont for the study of marsh birds on the refuge. That agreement has been in place for several years as an ongoing study. Its results are not only crucial for refuge management purposes, but also for the National Audubon Society statistical purposes. Finally, the refuge has a coop agreement with the Vermont YCC for annual work periods on the refuge. These always take place in the summer, usually July and August for a two or three week period when a crew comes to the refuge to work on various public use or habitat management projects. The refuge pays the Vermont YCC who then handles all the administration, supervision, and oversight for the program, allowing the refuge staff to focus on organizing and coordinating the projects. This is highly beneficial to both parties.

Along with cooperative agreements, the refuge shares Memorandums of Understanding (MOUs) with other agencies such as local fire departments, the Border Patrol, the sheriff's department, and state agencies. The purpose of those MOUs is to provide essential support to the refuge. MOUs with local fire departments insure support for controlled burns, while MOUs with the Border Patrol, the sheriff's department, and state agencies give the refuge shared radio frequencies and law enforcement backup as needed.

Special Use Permits

The refuge issues special use permits to individuals, organizations, and educational facilities for an array of requests, some which are out of the realm of regularly allowed refuge activities or use of its resources. Permits are time-specific: each carries a starting date, ending date, and the specific terms and conditions for each request. On average, the refuge issues 16 special use permits each year to a variety of users.

To improve migratory bird habitat on refuge land, haying partners are granted special use permits. Local farmers pay \$6 an acre to cut and bale the hay produced on refuge grasslands yearly. Grasslands must be periodically mowed to control weeds and prevent the regrowth of trees and shrubs. That arrangement benefits the refuge by reducing our grassland mowing workload, and provides participating farmers with supplemental hay. Mowing is not allowed until July 15, after the nesting season for grassland-dependent migratory birds.

Special use permits also allow local anglers and bait dealers special access through the refuge to the Missisquoi River to retrieve minnows for bait used in the winter fishing season.

In addition, the refuge issues special use permits for trapping on the refuge, which is also a refuge management practice. Due to the low level of requests, the refuge currently does not charge a fee for trapping permits.

Many special use permits for research have been issued for such purposes as archaeology surveys, black tern surveys, and frog surveys. Those permits entail access into closed refuge areas paramount in the research.

The refuge also issues special use permits to environmental education organizations for access into closed areas for educational purposes and special viewing opportunities.

Wilderness Review

We completed a wilderness review of the refuge in 1974, and sent a proposal based on refuge management needs and the public input we had received at that time to the U.S. Department of the Interior. We proposed the following two contiguous areas for wilderness which we now refer to collectively as the “Shad Island Proposed Wilderness Area”: (1) Shad Island, and (2) the refuge land and shoreline from the East Branch of the Missisquoi River to Martindale Point. Congress has neither accepted nor rejected that proposal; a decision has been pending for more than 30 years. Meanwhile, the refuge and its environs have changed. Recently, as part of this comprehensive conservation planning process, we once again reviewed all portions of the refuge for possible wilderness designation. The results of this review are included in Appendix A.

Partnerships

A crucial component in implementing this Comprehensive Conservation Plan (CCP) and enhancing refuge resources is to develop and expand our partnerships with other environmental agencies, local school districts, and community groups. See chapter 5 for more on partnership opportunities. We will continue to improve biological and environmental research and monitoring through an enhanced partnership with UVM and the VT FWD. Environmental education opportunities will benefit from expanded partnerships with the Franklin County School Board, local schools, and the VT FWD. The lack of refuge staffing and funding is the limiting factor in those partnerships to nurture those programs.

Local organizations that have contributed to the operation of the refuge include the Swanton and St. Albans Chambers of Commerce, Swanton Historical Society, Audubon Vermont, Ducks Unlimited (DU), the Sportsman’s Club of Franklin County and the LCBP. In addition, private individuals who volunteer to assist with various projects have been and will continue to be an important partnership factor. We have established personal contacts and working relationships with other organizations, including the VT FWD, Franklin County School District, Swanton Selectboard, Highgate Selectboard, and Swanton Village Trustees.

In 2002, the Friends of Missisquoi National Wildlife Refuge, Inc. was established. The Friends group is a non-profit organization that helps fund education, interpretation, and outreach programs at the refuge. The Friends of Missisquoi continue to improve outreach to the local community, and are dedicated to promoting public awareness and appreciation of the natural and cultural history of the Missisquoi River Basin by providing natural history talks, seminars, and publications. The Friends are also concerned with the preservation of Missisquoi Refuge and the maintenance of its essential wildlife habitats.

Volunteer Programs

In addition to dynamic partnerships with organizations, the refuge is fortunate to have a small but dedicated group of individuals who voluntarily assist the refuge in various projects. For example, 75 volunteers donated 1,894 hours in 2004 to assist in environmental education programs and outreach events, conduct wildlife and habitat surveys, provide visitor services, band birds, manage habitats and species, and carry out general maintenance tasks. In addition to helping the refuge achieve its objectives and strategies, that cadre of volunteers serves as an important link with the community at large, promoting refuge messages and garnering support for the Refuge System.

Refuge Biological Resources

Research Natural Areas (RNA)

The Service cooperates with many other agencies and organizations to establish and preserve a diverse, representative network of plant and animal communities of different ecological types, managing each in a natural state for research purposes. RNAs are intended to represent the full array of North American ecosystems: biological communities, habitats and phenomena, and geological and hydrological formation and conditions. They are areas where natural processes are allowed to predominate with little or no human intervention. However, the Refuge Manual states that RNAs “must be reasonably protected from any influence that could alter or disrupt the characteristic phenomena for which the area was established.” Therefore, if removing predators or disrupting relations in natural communities has created conditions under which certain species multiply beyond normal limits and pose a disruptive threat, controlling those populations through human intervention may be necessary.

The Missisquoi Refuge has two RNAs: the Maquam Bog RNA and the Shad Island RNA (map 3–4). The Maquam Bog RNA, located southwest of State Route 78, was established in 1992. The 890-acre RNA is a large sphagnum bog with a diverse mix of plants. It supports one of the largest populations of rhodora in Vermont. The bog contains a fringe of maples with highbush blueberries in the understory. Sedges and cranberry vines dominate the center of the bog, which is a little higher. Several small stands of pitch pines also are present in the center. The RNA also hosts a large population of Virginia chain fern, a state-listed threatened plant species.

The Shad Island RNA was established in 1968. It is located at the extreme northern end of the refuge, and is the northernmost terminus of the Missisquoi River Delta. Shad Island, measuring approximately 120 acres, contains a mix of silver maple, swamp white oak, green ash, and cottonwood trees on an area that has been little altered by past land use practices. The RNA is home to the largest great blue heron rookery in Vermont, and provides extensive research opportunities for scientists concerned with herons, their habitat, and their interactions with double-crested cormorants.



Heron Rookery

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Soils

Most of the refuge is composed of hydric soils—poorly drained soils with high water near, at, or above the surface—although there is a small region of dryer upland soil at the western boundary of the refuge along Tabor Road on Hog Island. The northern half of the refuge is dominated by the Missisquoi delta, formed from the deposition of sediments by the river’s normal flow and floods. Table 3.6, below, and map 3–5 describe the soil characteristics on and around the refuge.

Table 3.6. Soils mapped on the refuge [from the Franklin County Soil Survey (1994)].

Soil Code	Soil Name, Slope	Origin	Drainage
BeB	Belgrade silt loam, 2–8% slope	Old lake plains	Moderately well-drained
Bg	Binghamville silt loam	Old lake plains	Poorly drained
Br	Birdsall silt loam	Lacustrine deposits	Very poorly drained
Ce	Carlisle muck	Depressions, bogs	Very poorly drained
Cv	Covington clay	Old lake plains	Poorly drained
DeB	Deerfield loamy fine sand, 0–8%	Old lake plains	Moderately well-drained
GeA	Georgia stony loam, 0–3%	Glacial till	Moderately well-drained
GeB	Georgia stony loam, 3–8%	Glacial till	Moderately well-drained
KbA	Kingsbury clay, 0–3%	Old lake plains	Somewhat poorly drained
Le	Limerick silt loam	Recent alluvial deposits	Poorly drained
LoB	Lordstown loam, rocky, 3–8%	Glacial till	Well-drained
LoC	Lordstown loam, rocky, 8–15%	Glacial till	Well-drained
LoD	Lordstown loam, rocky, 15–25%	Glacial till	Well-drained
Ly	Lyons stony loam	Glacial till	Poorly drained
Ma	Marsh		Very poorly drained
MeA	Massena stony loam, 0–3%	Glacial till	Somewhat poorly drained
MnA	Massena extremely stony loam, 0–6%	Glacial till	Somewhat poorly drained
Ru	Rumney Variant silt loam	Recent alluvium	Poorly drained
SaB	St. Albans slaty loam, 3–8%	Glacial till	Well-drained
ScA	Scantic silt loam, 0–3%	Old lake plains	Poorly drained
Tm	Terric Medisaprists	Depressions, bogs	Very poorly drained
Wa	Walkkill silt loam	Alluvial	Very poorly drained
Wt	Winooski silt loam	Recent alluvial deposits	Moderately well-drained

The dominant soils in the Missisquoi River floodplain and tributaries are the poorly drained Limerick (Le), very poorly drained Walkkill (Wa) silt loams, and organic Marsh (Ma). Rumney Variant (Ru) and Winooski (WT) are found along the river as it flows into the refuge. A gradation from coarser to finer alluvial deposits away from the river occurs because the river is less able to transport and deposit material along its margins.

In the southern half of the refuge, organic soils form the Maquam Bog and the Black and Maquam creeks area to the east. The central bog is composed of

Carlisle (Ce) muck, a very productive soil type. These organic soils are at least 5 feet deep, and may be up to 8 feet deep. Bordering those soils are shallower organic Terric Medisaprist (Tm) soils. The organic layer is about 2 feet thick, and overlies loamy soils.

Lordstown rocky loam (LoC) and Georgia stony loam (GeB) underlie distinctive islands of oak forest at the western edge of Maquam Bog. These soils are well drained, in contrast to the very poorly drained organic soils of most of the bog. Drainage, as well as hydrology, directly affects the soil types, and, in turn, the type of vegetation present on the refuge.

A mosaic of soil types, as shown on map 3-5, underlies the Tabor Road—Hog Island section of the refuge. Those include some of the better drained soils on the refuge, reflected in the agricultural land uses on Hog Island.

Plant Communities

Clews (2002) used the natural community classification presented by Thompson and Sorenson (2000) to map the plant communities at Missisquoi Refuge. Clews (2002) used existing refuge resource inventories and maps, black and white orthophotos, color aerial photography, field inventories, and the Geographic Information System (GIS) to create a natural community map of the refuge (map 3-6). That coarse filter approach to mapping existing vegetation types provides a baseline map for the refuge. The Missisquoi River Delta is a dynamic environment that requires periodic monitoring to document its changing conditions.

More than 90 percent of the Missisquoi Refuge is wetland or open water habitat. Table 3.7 describes the natural community types and other land uses mapped by Clews (2002) for the refuge. Thompson and Sorenson (2000) define a natural community as “an interacting assemblage of organisms, their physical environment, and the natural processes that affect them.” Natural communities, as defined here, are those that have experienced minimal human alteration or have had sufficient time to redevelop primarily through natural processes. By definition then, these descriptions focus on mid-to-late successional stages, and exclude human-altered landscapes and early successional habitats (Thompson and Sorenson 2000). However, although the excluded areas do not receive a natural community identifier and associated description, they are important for wildlife habitat, and are included in the Clews (2002) map as other land uses.

Table 3.7. Natural communities and other cover types on the refuge.

Natural Community	General Location	Refuge Area (acres)	Percent of total land cover within refuge	Indicator Plant Species (dominant in boldface)
Silver maple-sensitive fern floodplain forest	Gallery forests form along edge of Missisquoi River and saturated marshes.	1,048	16	Silver maple Sensitive fern American elm Cottonwood Green ash Swamp white oak
Sedge meadow	Between floodplain forest edge and buttonbush colonies	702	11	Tussock sedge Giant bur reed Broad-leaved cattail Blue flag Wild rice
Wild rice marsh	Standing water 1-2 feet. Mixed in with buttonbush and sedge marshes.	664	10	Wild rice Buttonbush Giant bur-reed
Buttonbush swamp	Forms colonies in wild rice marsh throughout wetlands on refuge	614	9	Buttonbush Wild rice
Alder swamp (High shrub zone)	Surrounding Maquam Bog	548	8	Speckled Alder Eastern larch Shadbush Rhodora Gray birch Cinnamon fern
Mixed shrub sedge bog	Center of Maquam Bog	435	7	Leatherleaf Hair's tail cottongrass Few seeded sedge Chain fern Rhodora Sphagnum spp.
Dwarf shrub bog	Periphery of Maquam Bog	408	6	Highbush blueberry Huckleberry Sheep laurel Rhodora Few-seeded sedge Sphagnum spp.
Red maple-green ash swamp	Backwater swamps and cut off ox bows	228	4	Red maple Green ash Silver maple American elm Dogwood

Natural Community	General Location	Refuge Area (acres)	Percent of total land cover within refuge	Indicator Plant Species (dominant in boldface)
Mixed grassland	Cultivated and planted along road sides, replacing old agricultural fields and cut down flood plain forest	223	3	Reed canary grass Rice cut grass Bluejoint grass Japanese knotweed
Pitch pine woodland bog	Periphery of Maquam Bog	179	3	Pitch pine Gray birch Rhodora Chain fern Highbush blueberry Hare's tail cottongrass
Dogwood – birch forest	Border of fields, river and Maquam Bog	54	<1	Cornus spp Paper birch White pine White oak Shadbush Aster spp
Dry oak forest	On gravel islands at western edge of Maquam Bog	47	<1	White Oak Red Oak Huckleberry Low sweet blueberry Poverty grass
Deep broadleaf marsh	Along rivershore in standing water	46	<1	Broad-leaved arrowhead Yellow and White waterlily Common cattail
Bulrush marsh	On outer margins of lake shore, water 1-5 feet deep	28	<0.5	Soft-stem bulrush Hard stem bulrush Water chestnut
Northern hardwood forest	Forested upland areas on old river berms and other well-drained soils.	24	<0.5	American beech White pine Yellow birch Cornus spp.
River mud shore	Summer-fall, along most of rivershore	20	<0.5	Rice cutgrass Slender beakrush Woolgrass
Rivershore grassland	Bars and points along rivershore	19	<0.5	Reed canary grass Bluejoint grass Joe-pye weed

Natural Community	General Location	Refuge Area (acres)	Percent of total land cover within refuge	Indicator Plant Species (dominant in boldface)
Open water and seasonal water		947	15	
Agricultural		214	3	
Road		11	1	
Railroad		4	<0.1	
Developed		0.21	<0.1	
Total Refuge Area (acres)		6,466*		

*Clews' 2002 analysis does not include some of the acreage on the western refuge boundary, so this number is less than the total refuge acreage.

The Vermont Nongame and Natural Heritage Program identifies several “significant natural communities” on or adjacent to Missisquoi Refuge as shown in Table 3.8. Some of these communities extend outside the refuge boundaries and Natural Heritage reports may include only those portions on State-owned lands.

Table 3.8. Significant natural communities on or near the refuge.

Natural Communities	State Rank	Condition*
Buttonbush Swamp	S2	B
Deep Bulrush Marsh	S4	A
Dwarf Shrub Bog	S3	A
Lake Sand Beach	S2	C
Lakeside Floodplain Forest	S3	A
Pitch Pine Woodland Bog	S1	Not ranked
Red or Silver Maple-Green Ash Swamp	S3	A
Silver Maple-Sensitive Fern Riverine Floodplain Forest	S3	A
Sweet Gale Shoreline Swamp	S3	A

*A = excellent; B = very good; C = good; D = fair
 Information provided by the Vermont Department of Fish and Wildlife, Nongame and Natural Heritage Program, February 24, 2006. See appendix C for definitions of state ranks.

The comprehensive conservation planning team used the natural community and land use map prepared by Clews (2002) as a base map for identifying priority habitat objectives. Some natural community types were combined to create a habitat objective that corresponded to the habitat conditions on the refuge and more effectively develop management strategies to benefit wildlife. For example, wild rice marsh, sedge meadow, buttonbush swamp, deep broadleaf marsh, and bulrush marsh were combined into a Lakeshore Wetland habitat objective, because those natural community types form a continuum of wetland conditions in the Missisquoi River Delta, and any management strategies would effect the overall lakeshore wetland habitat (see chapter 2 for more detail on habitat objectives).

Wetlands and Open Water Communities

Silver maple-sensitive fern floodplain forest (1,048 acres)

The refuge contains the largest contiguous acreage of floodplain forest in Vermont (Sorenson 1998), with more than 1,000 acres along the lower Missisquoi River. In addition to silver maple, the floodplain forest contains eastern cottonwood, swamp white oak, green ash, and American elm, with a lush understory of sensitive fern. The forest is flooded each spring and is easily navigable by canoe for much of May. As the waters recede, large quantities of woody debris, seeds, and fertile soil are left behind. As the soil dries out, millions of seedlings cover the forest floor.

The wealth of bird species found in the floodplain forest is greater than anywhere else on the refuge. Migratory songbirds use the floodplain forest for nesting,

foraging, and as a stopover in spring and fall. The floodplain forest is important for breeding migratory songbirds of conservation concern including wood thrush, veery, black-billed cuckoo, Canada warbler, rose-breasted grosbeak, and Baltimore oriole. Missisquoi Refuge has the second highest abundance of breeding orioles among the refuges in the Northeast. Great blue herons and double-crested cormorants nest in the silver maples at the northern end of the delta on Shad and Metcalfe Islands. Wood duck, common goldeneye, and hooded merganser are three cavity nesters that breed in the refuge floodplain forest along with black duck and mallard.

Emergent wetlands: sedge meadow, buttonbush swamp, wild rice marsh (1,980 acres)

These three communities are closely related and are found together throughout the refuge. They are distinguished by three different dominant species: tussock grass, buttonbush, and wild rice, respectively. These three species are nearly ubiquitous across the permanently saturated wetlands of the Missisquoi Delta and form a productive matrix of wetland habitat on the refuge. These wetland communities are seasonally inundated as the lake level rises each spring, and are covered by five to 12 inches of standing water by early summer. The soils are generally shallow and composed of organic muck.

Emergent wetlands: deep broadleaf marsh (46 acres)

This community is found in shallow water and often forms dense mats of vegetation along the slower-moving portions of the river. The water level fluctuates with the seasons, but is on average six inches to three feet deep. Fish use these shallow waters to spawn and forage. Common plants include pickerelweed, broad-leaved arrowhead, and giant bur-reed. This natural community type is common in Vermont.

Emergent wetlands: deep bulrush marsh (28 acres)

These marshes are found along the outer margins of the delta in coarse sandy soils. They grow in one to four feet of water at the lake's edge where they are subject to lots of wave wind action. This plant community is dominated by soft and hard-stem bulrush, and does not support high plant diversity. Black terns perch on old tree trunks in the middle of the bulrush marsh and pied-billed grebes and common moorhens forage among the soft rushes. Bulrush marshes are common along the shore of Lake Champlain and smaller lakes and rivers across Vermont.

Red maple-green ash swamp (228 acres)

This community type is found south of the old Refuge headquarters around Black Creek. In addition to the dominant red maple and green ash, slippery elm, alder sp., dogwood sp., and white birch are abundant. This swamp is stratified with a thick mid-story. Cinnamon and ostrich ferns carpet the forest floor in some places. Probably because of the more complex structure of this swamp, the Black Creek area supports all of the usual floodplain forest bird species, as well as several others species, such as the blue-gray gnatcatcher, that are found nowhere else on the refuge. Red maple-green ash swamps in Vermont are mostly along Lake Champlain typically in former bays of the lake and now separated by naturally formed sand or shale berms (Thompson and Sorenson 2000).

Maquam Bog

The 900-acre Maquam Bog, one of Vermont's largest bogs, contains the state's largest populations of rhodora, as well as pitch pine, and Virginia chain fern, a state-threatened species (map 2-1). The center of the bog is about 100 feet above sea level, with an overall hummock-hollow relief of less than 8 inches. A natural gravel berm separates the bog from Maquam Bay to the south, Charcoal Creek,

an old distributary of the Missisquoi River, defines the northern border, and the uplands of Hog Island form the western border (Strimbeck 1988).

Strimbeck (1988) identified three distinct vegetation zones in the bog: shrub-sedge, low shrub, and high shrub. Clews (2002) classified these as follows:

Mixed shrub sedge bog (435 acres)

This community forms the heart of Maquam Bog and is one of the largest examples of an ombrotrophic bog in New England. Peat mosses form a thick lumpy mat throughout this community, which is quite unstable in some places. Virginia chain fern and few-seeded sedge are found here and are both listed as rare plant species. This area of the bog also provides potential nesting for short-eared owls and northern harriers, birds uncommon in the State of Vermont. Preservation of this community may require removal of the small trees and shrubs that are encroaching from the perimeter of the bog as well as maintenance of the current hydrological processes.



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Virginia Chain Fern

Dwarf shrub bog (408 acres)

This community type supports both plant and birds species commonly found further north or at higher elevations. Sheep laurel and leatherleaf are abundant, and the occasional song of a winter wren or white-throated sparrow can be heard here. Gray birch, tamarack and red maples form patches of taller forest, but the vegetation in this community is generally less than six feet tall. This community forms the matrix landscape around the patches of pitch pine woodland bog and is also a rare community in the state of Vermont.

Pitch pine woodland bog (179 acres)

This is the only example of this natural community type known to occur in Vermont and occurs in small patches among the mixed and dwarf shrub bog communities.

Alder swamp (548 acres)

This community type surrounds Maquam Bog and is an integral part of the bog ecosystem. In addition to speckled alder other species include huckleberry, highbush blueberry, shrubby willows, dogwoods, and mountain holly are abundant in this swamp. Huge hummocks are formed by the thick rhizome masses of several fern and sphagnum moss species. The uneven terrain and thick brush make this community hard to navigate, effectively blocking entrance to Maquam Bog.

Rivershore grassland (20 acres)

Because of the similarity between river and lakeshore grasslands, and the ambiguous gradation between lake and river on the Missisquoi Delta, both communities are classified as rivershore grassland. These communities follow the length of the Missisquoi River and the lakeshore to either side. The shoreline is seasonally scoured by river and lake ice, then flooded during the

spring thaw, and finally left high and dry by mid-June. These communities often form the transition zone between river mud shore and floodplain forest communities.

River mud shore (20 acres)

These transient communities exist on the slim margin of land that emerges as the Missisquoi River recedes in mid summer. They are often bordered by rivershore grassland and share many of the same species. Because of their proximity to the river (which is a source of both disturbance and seeds), these communities are prone to supporting invasive species. Fortunately, the most common of these species, purple loosestrife, is rare on the refuge. However, flowering rush and common barnyard grass are two abundant invasive species found in this community. Raccoon, muskrat, spotted sandpiper, and green frog are some of the native species that can be found here.

Uplands

Dry oak forest (47 acres)

These forests of northern red and white oak form small islands in the middle of the alder swamp at the western edge of Maquam Bog. The trees here are mature and form a nearly complete canopy. The transition to this community type is abrupt and closely follows the border between soil types.

Northern hardwood forest (24 acres)

This forest, composed of American beech, yellow birch, red maple and sugar maple, is the matrix forest type of Vermont but is not common on the refuge. Northern hardwood forest requires well-drained soils and is found on the upland areas within and surrounding the refuge.

Dogwood-white birch forest (54 acres)

This community type is found along slopes above wetland areas. Dogwood forms a thick shrub layer and birch trees form the canopy. This community forms the transition zone between the alder swamp on the west side of Maquam Bog and the field along Tabor Road.

Mixed grassland (437 acres)

This community type is dominated by reed canary grass. In some areas these fields are mowed, hayed, and/or burned. Depending on the diversity of grass species, these fields support bird and mammal species to varying degrees. The least productive areas appear to be the northeast side of the Missisquoi River and some of the fields west of the old Refuge headquarters due to a monoculture of reed canary grass. In areas that were formerly floodplain forest, on either side of the Missisquoi River along Route 78, Limerick and Winooski silt loams occur and in the grasslands along Tabor Road on Hog Island, there is a more complex association of soil types, leading to higher wildlife diversity.

Impoundments

Water management on the refuge occurs on approximately 1,250 acres in two water management units: Goose Bay-Big Marsh Slough (Unit 1) and Cranberry Pool (Unit 2). Three incomplete dike sections impound the two management units. An 800' long dike closes off the drainage flow in Big Marsh Slough and contains a 4' corrugated metal pipe outlet equipped with stop-logs, that is currently inoperable. A 2000' long dike separates Goose Bay Pool from Goose Bay. Cranberry Pool is enclosed along its eastern, lower-elevation half by a 2.8-mile long earthen dike that contains one fully operable 4' water control structure. The Goose Bay Pool dike was completed in 1959, the Big Marsh Slough dike in the early 1960s, and the Cranberry Pool dike in 1970 (USFWS 1986). The purpose of these impoundments was to convert lower value wetlands into productive waterfowl habitat. The 1986 Refuge Water Management Plan also included a proposal to create three impoundments in Maquam Bog. This

proposal has been dropped given the ecological significance of the bog as a peatland.

In 1995, DU assisted the refuge in installing a water control structure at the Stephen J. Young marsh, creating a 2-acre permanent wetland.



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Haying refuge grasslands along Route 78

Grassland Management

A 1986 refuge grassland management

plan reported on the use of some grasslands by nesting waterfowl such as blue-winged teal and mallard, perhaps an occasional American bittern, and also used as spawning areas by northern pike. However, it wasn't considered optimal waterfowl nesting habitat at the time. In 1980, 9 acres of the #7 field, along Rt. 78 west of the Missisquoi River, was planted to reed canarygrass/birdsfoot trefoil mix in a pilot effort to improved duck nesting cover. This area is seasonally flooded. Seven acres of field #11 was planted to bromegrass/alfalfa mix in 1983. See map 2-2 for field locations. The 46-acre field #11a was grazed through 1979. This field is stony, low-lying, and wet. In 1992 a dike was installed in the marshy area creating a 2-acre wetland. The management emphasis on Refuge grasslands has shifted away from periodic re-planting and intensive management of fields to maintaining those that benefit grassland nesting birds through delayed mowing and allowing others to revert to shrubland or forest.

Federal and State Threatened, Endangered, or Special Concern Species

Missisquoi Refuge has no known Federally listed threatened and endangered plants or animals. There are several state listed threatened and endangered species or species of special concern on the refuge as listed in table 3.9.

Plants

Virginia chain fern and few-seeded sedge are state threatened and occur in Maquam Bog.

Animals

The refuge-portion of the Missisquoi River supports seven species of state threatened or endangered species of freshwater mussels (Marangelo 1999, Fichtel and Smith 1995). The Missisquoi Delta provides significant habitat for the eastern spiny softshell turtle, a state threatened species also listed as threatened by the Province of Quebec. The refuge provides important feeding and loafing habitat for this species, as well as some over-wintering habitat. Vermont's largest population of black terns, also a state threatened species, breeds on the refuge. The state endangered lake sturgeon is also present in the area, though not common. Appendix C lists additional species identified by the VT FWD as "species of greatest conservation need."

Table 3.9. Rare species on the refuge*

Scientific Name	Common Name	Global Rank	State Rank	State Status
Plants				
<i>Bidens discoidea</i>	Small Bidens	G5	S2S3	
<i>Ceratophyllum echinatum</i>	Prickly Hornwort	G4?	S1	
<i>Lysimachia hybrida</i>	Lance-leaved Loosestrife	G5	S1	
<i>Nyssa sylvatica</i>	Black Gum or Tupelo	G5	S2	
<i>Potamogeton vaseyi</i>	Vasey's Pondweed	G4	S2	
<i>Ranunculus flabellaris</i>	Yellow Water-crowfoot	G5	S3	
<i>Ranunculus pennsylvanicus</i>	Bristly Crowfoot	G5	S2	
<i>Sisyrinchium angustifolium</i>	Narrow Blue-eyed Grass	G5	S2	
<i>Woodwardia virginica</i>	Virginia Chain-fern	G5	S1	T
Fish				
<i>Acipenser fulvescens</i>	Lake Sturgeon	G3G4	S1	E
<i>Ammocrypta pellucida</i>	Eastern Sand Darter	G3	S1	T
<i>Hybognathus regius</i>	Eastern Silvery Minnow	G5	S2	
<i>Ichthyomyzon unicuspis</i>	Silver Lamprey	G5	S2?	
<i>Notropis heterolepis</i>	Blacknose Shiner	G4	S1	
<i>Notropis rubellus</i>	Rosyface Shiner	G5	S2S3	
Reptiles and Amphibians				
<i>Ambystoma laterale</i>	Blue-spotted Salamander	G5	S3	SC
<i>Apalone spinifera</i>	Spiny Softshell (Turtle)	G5	S1	T
Birds				
<i>Ardea herodias</i>	Great Blue Heron	G5	S2S3B	
<i>Chlidonias niger</i>	Black Tern	G4	S2B	E
<i>Circus cyaneus</i>	Northern Harrier	G5	S2B	SC
<i>Gallinula chloropus</i>	Common Moorhen	G5	S2B	
<i>Ixobrychus exilis</i>	Least Bittern	G5	S2B	SC
<i>Melanerpes erythrocephalus</i>	Red-headed Woodpecker	G5	S1S2B	SC
<i>Pandion haliaetus</i>	Osprey	G5	S2B	
<i>Podilymbus podiceps</i>	Pied-billed Grebe	G5	S2B	SC
<i>Porzana carolina</i>	Sora	G5	S2S3B	SC
Mussels				
<i>Anodontoidea ferussacianus</i>	Cylindrical Papershell	G5	S1S2	E
<i>Lampsilis ovata</i>	Pocketbook	G5	S2	E
<i>Lasmigona costata</i>	Fluted-shell	G5	S2	E
<i>Leptodea fragilis</i>	Fragile Papershell	G5	S2	E
<i>Ligumia recta</i>	Black Sandshell	G5	S1	E
<i>Potamilus alatus</i>	Pink Heelsplitter	G5	S2	E
<i>Pyganodon grandis</i>	Giant Floater	G5	S2S3	T

* Information provided by the VT FWD, Nongame and Natural Heritage Program, February 24, 2006. See appendix C for definitions of global and state ranks and state status.

Black Tern

The refuge supports Vermont’s largest population of black terns, a state-endangered species. In 2005, 103 pairs of black terns nested in Vermont, all on the Missisquoi Refuge. The distribution on the refuge included Charcoal Creek north of Rt. 78—52 pairs; Charcoal Creek south of Rt. 78—4 pairs; Long Marsh—28 pairs; and Cranberry Pool—19 pairs. The number of terns using the refuge fluctuates from year to year, but is consistently high. Beginning in 1999, the State’s entire nesting population was on Missisquoi Refuge. Table 3.10 summarizes black tern nesting in Vermont from 1990 to 2005 (Shambaugh 2002).



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Black Tern

Table 3.10. Estimated number of black tern breeding pairs on Lake Champlain and Lake Memphremagog, 1990–2005

Year	Missisquoi Population	Dead Creek	South Bay (Lake Memphremagog)	Total
1990	37	18	4	59
1991	50	17	4	71
1992	75	16	4	95
1993	63	**	**	**
1994	63	9	2	74
1995	56	5	3	64
1996	34	7	3	44
1997	53	1	5	59
1998	72	2	3	77
1999	97	0	3	100
2000	63	0	0	63
2001	53	0	0	53
2002	66	0	0	66
2003	67	0	0	67
2004	66	0	0	66
2005	103	0	0	103

** no data

Spiny softshell turtle

The Missisquoi River Delta provides significant habitat for the eastern spiny softshell turtle. The Province of Quebec and the State of Vermont list it as a threatened species. All of its known hibernation (wintering) sites are in Vermont. The Missisquoi delta population uses nesting, resting, and feeding habitat on both sides of the international border. The refuge provides important feeding and loafing habitat for the spiny softshell. This turtle is susceptible to disturbance by humans, predation by raccoons, skunks and foxes, and pollution.

The spiny softshell turtle is distinguishable by its long, snorkel-like snout and flat, leathery, pancake-like shell. From May through September, turtles are often seen basking on logs along the main branch of the Missisquoi River. They also bask in the upper portion of Dead Creek and along the Cranberry Pool east dike. Limited over wintering habitat exists on the refuge and on portions of the Missisquoi River; most is in deeper water near the existing causeway that spans Lake Champlain between West Swanton and Alburg. That site is a good basking site, and may provide an abundance of crayfish, an important food source. The spiny softshell hibernates from September to April. No nesting occurs on the refuge, although a significant nesting beach has been identified at the Sandy Point beach nearby on the Carmen's Marsh WMA.

Other Fish and Wildlife

Birds

The refuge provides habitat for more than 200 species of birds, including thousands of migratory waterfowl during fall migrations, and is an important breeding area for waterfowl and other migratory birds. Fall populations of waterfowl often peak at 20,000. The largest great blue heron rookery on the Vermont side of Lake Champlain is located on Shad and Metcalfe Islands. In 2005, 266 great blue heron nests were counted in this rookery. The refuge also supports breeding populations of numerous other species, such as rails, bitterns, common moorhens, pied-billed grebes, and numerous grassland, wetland and forest passerine species. In addition, wild turkeys are observed on the refuge, because of efforts by the VT FWD to establish flocks in Franklin County.



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First Creek Osprey Platform

Double-crested cormorants increasingly frequent Shad Island and adjacent Metcalfe Island. The total nesting population of cormorants has increased steadily since 1996, and reached 86 pairs in 2005. However, very limited nesting success has been recorded. Only one cormorant nest is known to have been successful in both 1999 and 2000, and none in 2005. Since 1999, UVM College of Natural Resources has assisted the refuge in monitoring those two populations, observing and recording interactions between the species, and recording the effects of the cormorants on the great blue herons and their nesting habitat.

Waterfowl nest boxes have been maintained on the refuge for more than 40 years. Wood ducks, common goldeneyes, and hooded mergansers use

them. The refuge maintains 130 nest boxes for those species; 61 percent of the boxes were used in 2000. In addition, about 12 structures intended for use by black ducks or mallards are located on the refuge. However, those nesting structures have not been used.

From 1989 to the present, the population of nesting osprey has increased from one pair on a platform in Long Marsh to a total of 20 pairs nesting on the Missisquoi River Delta in the 2002 nesting season, and 27 in the 2004 nesting season. Figure 3.2 shows the relative locations of osprey nests near the Missisquoi River Delta in 2004.



Figure 3.2. Osprey nesting locations on the Missisquoi River Delta (2004)

We have used a point count survey since 1994 to monitor breeding land bird abundance in grassland and floodplain forest habitats on the refuge. That is not long enough to predict population trends, but it does provide baseline information. Data collected each June from 1994 to 2001 provides those values. Figures 3.3 through 3.7 from Clews (2002) show the diversity of bird species across a suite of habitats on the refuge based on the 50 annual songbird point counts there.

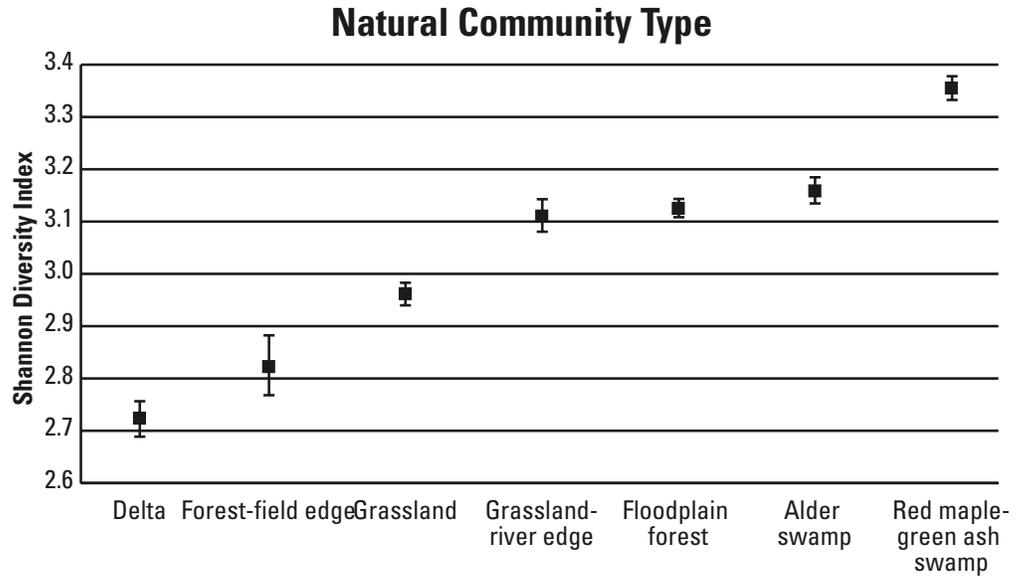


Figure 3.3. Shannon Diversity Index for bird species in seven habitat types on the Missisquoi Refuge (Clews 2002)

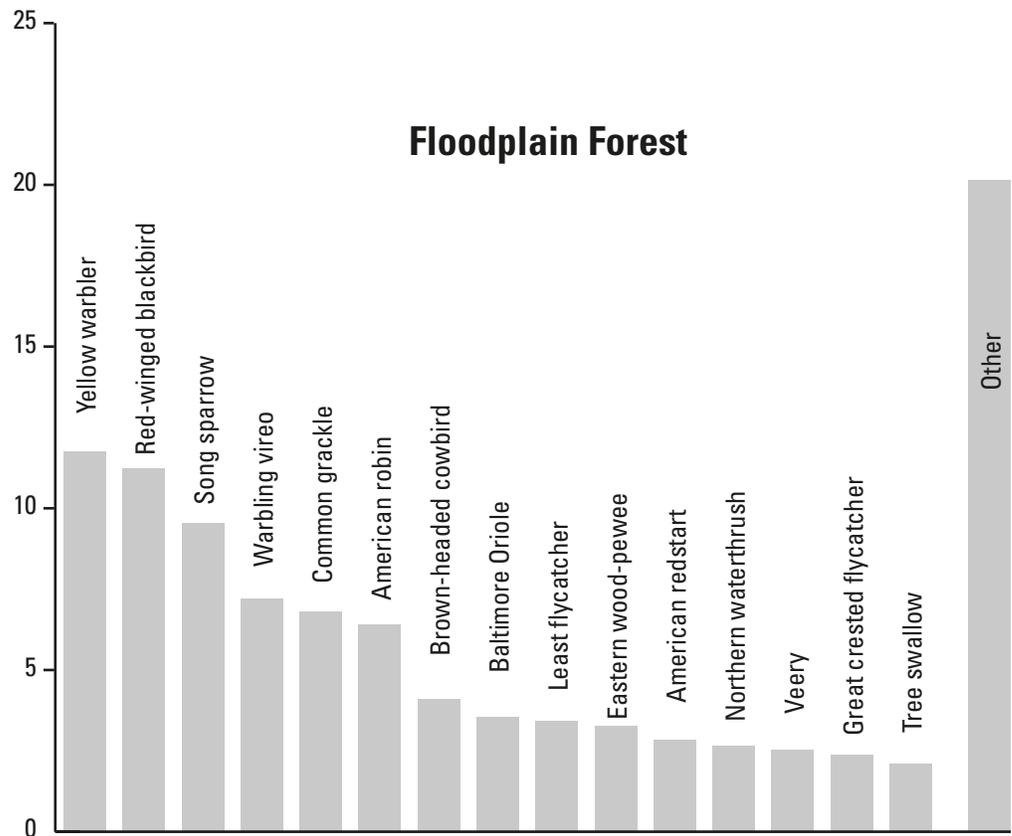


Figure 3.4. Bird species composition in floodplain forests on the Missisquoi Refuge based on point count surveys (Clews 2002).

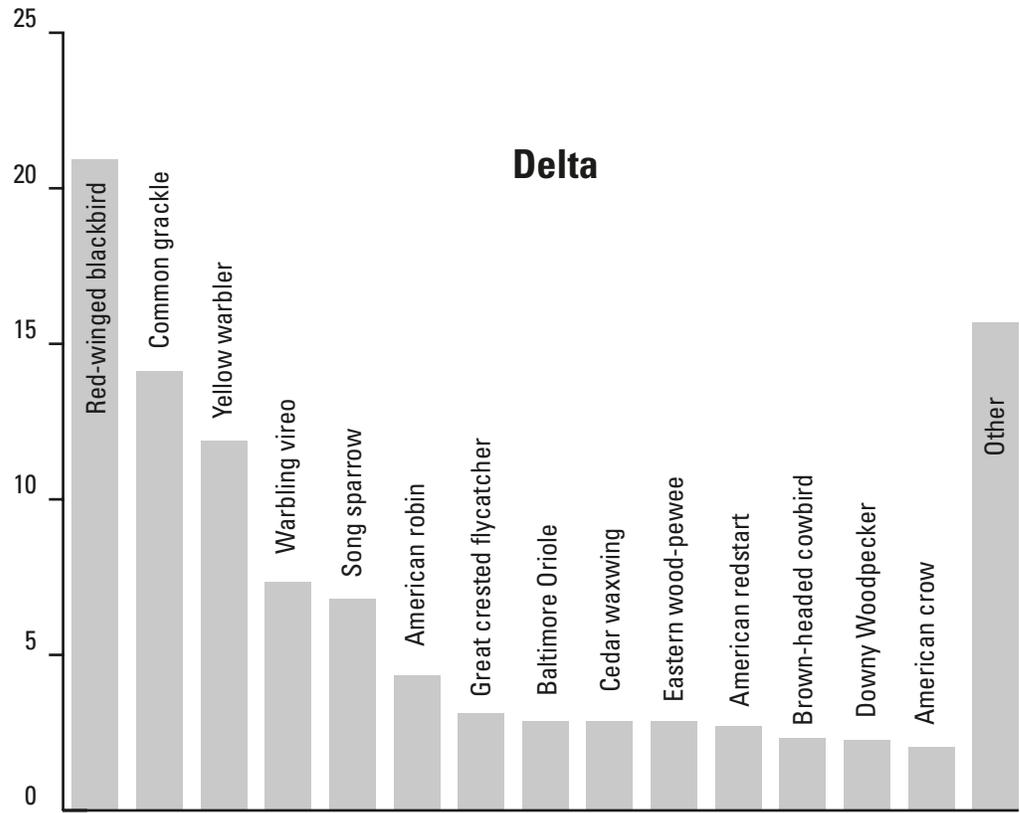


Figure 3.5. Bird species composition in the Missisquoi River Delta based on point counts surveys (Clews 2002).

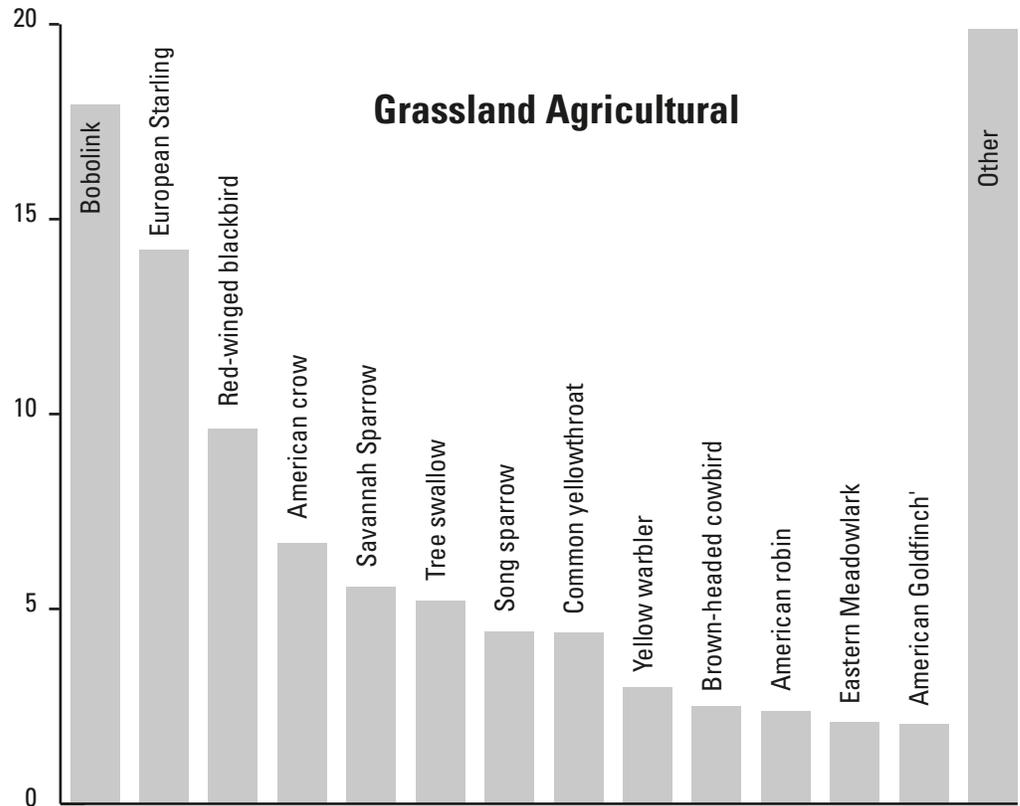


Figure 3.6. Bird species composition in grassland-agricultural habitats on Missisquoi Refuge based on point count surveys (Clews 2002).

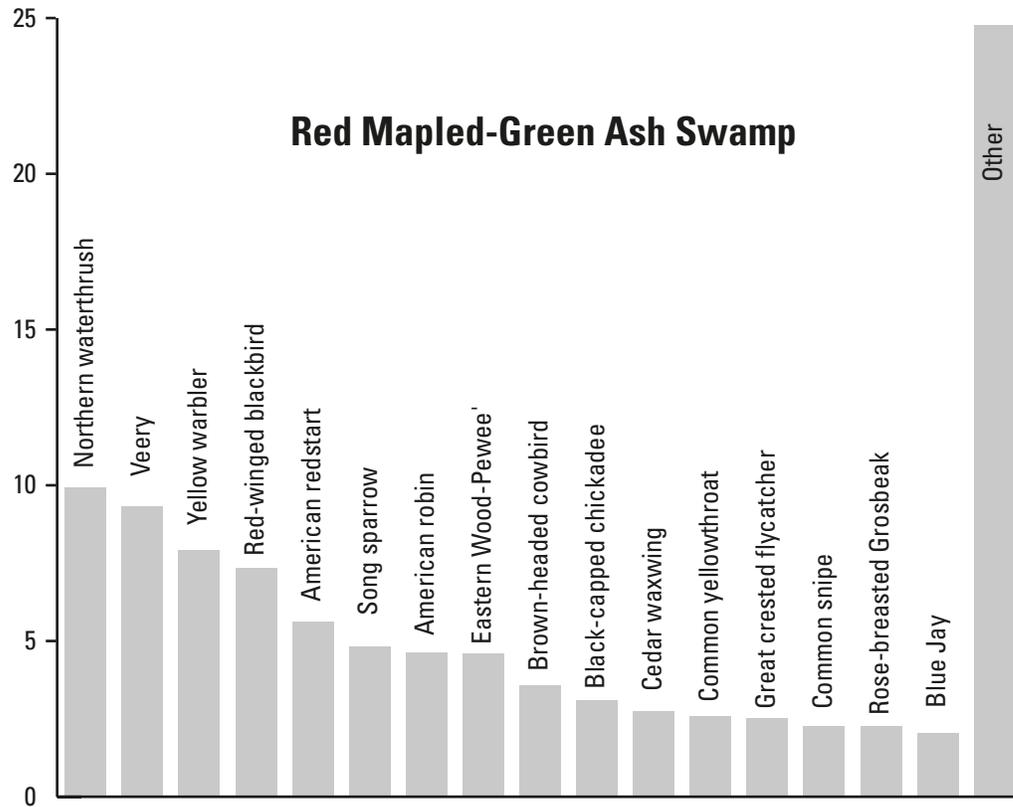


Figure 3.7. Bird species composition in red maple-green ash swamp on Missisquoi Refuge based on point count surveys (Clews 2002).

Fish and Aquatic Invertebrates

The Missisquoi River and Missisquoi Bay provide habitat for numerous fish and aquatic invertebrates, both common species and threatened or endangered species. The low-lying marshes and shallow aquatic weed beds of the refuge, which flood during the spring snow melt and ice-out periods of April and May, serve as critical feeding, spawning, and nursery grounds for those species. Meadows and fields along the river, as well as the shallow, sloping, grassy dikes of Cranberry and Goose Bay Pools are also excellent habitats for numerous fish species, especially northern pike, pickerel, and yellow perch. Those populations are very important as food sources for waterfowl broods, and marsh birds, both adults and young.

Our Lake Champlain Fish and Wildlife Resources Office sampled fish in the Missisquoi River from its mouth to 10 miles upstream in July and August 1994, and documented the presence of 24 species. The Vermont Department of Health has issued fish consumption advisories because of high levels of mercury for several fish species in the Missisquoi River, including walleye. The lake sturgeon and eastern sand darter are state-listed as endangered and threatened, respectively.



Walleye

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Like many other rivers in the Northeast, a history of human-induced modifications has limited access to historical spawning sites. Fish are now limited in their upstream passage by the Swanton Dam. The Service determined that the amount of spawning substrate for walleye and sturgeon was not a limiting factor in the river. However, the quality of spawning locations varies with stream flow, and is limited by water depth and velocities during the spring spawning periods. Much more spawning habitat is available above the dam. However, the fish cannot reach that area now.

The list of state record fish taken by rod anglers and bow anglers further illustrates the richness of refuge fish and aquatic resources. Many records come from the vicinity of the refuge, including the bow and arrow records for carp, redhorse sucker, and bowfin, and the hook-and-line records for bowfin, sucker, and muskellunge. A 38-pound state record muskie was caught in the Missisquoi River in 2005.

Freshwater Mussels

The Missisquoi River supports an abundant, diverse freshwater mussel community: 12 species are known to live in the lower Missisquoi River, but not all within refuge waters. Eight freshwater mussels, including the pink heelsplitter, fragile papershell, giant floater, cylindrical papershell, pocketbook, eastern lampshell, eastern elliptio, and eastern floater pocketbook live in the refuge-stretch of the river (Fichtel and Smith 1995). The black sandshell and fluted-shell probably occurred in the Missisquoi River below Swanton dam at one time, but there is no evidence that they are still alive there, and there is no historical information that those two state-listed endangered species lived as far downstream as the refuge (Mark Ferguson, Vermont Fish and Wildlife, pers. comm.). The Vermont Wildlife Action Plan (WAP) (VT FWD 2005a) identifies all of those species as “species of greatest conservation need.

Mammals

The refuge supports a diversity of native wildlife, including 35 species of mammals. Muskrat, beaver, and white-tailed deer sign or sightings are common. In recent years, the diversity of the indigenous wildlife has increased. Moose use various areas of the refuge, especially during 1999 and 2000. In 1999, a black bear was killed crossing Route 78 where it



White-Tailed Deer

passes through the refuge. A number of small mammals use various habitats on the refuge year-round. Eastern pipistrelle and little brown bat are both common on the refuge. Biologists have searched for the federal-listed endangered Indiana bat, but have not detected any on the refuge.

The muskrat is a prominent species of the emergent wetlands of the Missisquoi River Delta. They are occasionally seen swimming across open water or sitting on vegetation eating cattails, but are most evident by their houses,

built of bulrush, mud, and other aquatic plants, scattered across the marsh. Muskrats are natural managers of wetlands. They feed on cattails and other aquatic vegetation, affecting the proportion of open water to vegetation that is beneficial to other aquatic wildlife. However, if they become overly abundant, they can eat out the vegetation. Muskrats also cause some damage on the refuge when they burrow into the impoundment dikes and cause leaks. We survey the dikes annually for muskrat damage by walking along them, looking for “runs” or trails just below the water surface that lead to a burrow. Muskrats also leave droppings along the bank or on logs or structures that they can easily climb upon, providing another way to detect their presence. We fill in any burrows we discover in the dike to prevent further damage or washouts.

Reptiles and Amphibians

In addition to the spiny softshell turtle described above, other turtles on the refuge include snapping turtle, map turtle, and the eastern painted turtle. The painted and map turtles frequently are observed basking on partly submerged tree limbs in the Missisquoi River. The eastern garter snake and the northern water snake are common on the refuge.

Frogs are abundant and diverse on the refuge. Species include the northern leopard, green, mink, pickerel, and wood frogs and bullfrog. Until recently, the refuge allowed “frog picking,” the collection of frogs for bait. That practice has been discontinued and is no longer an allowed use.



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Conducting frog sampling

Since 1996, the Service and the University of New Hampshire (UNH) biologists have surveyed the Missisquoi Refuge and several other refuges in the Northeast for abnormal amphibians (Pinkney et al. 2005). An abnormality is either a malformation or a deformity. A malformation occurs when something goes wrong during development, causing a body part or an organ to form improperly. A deformity is the result of an existing body part that becomes disfigured (e.g., a missing foot due to a predatory attack). Since a deformity is typically the result of a natural relationship (e.g., a predator-prey interaction), scientists have focused their efforts on determining the cause of malformations.

Amphibians are sensitive to environmental changes, and are considered indicators of environmental quality. Refuges in the Northeast have a 0- to 10-percent rate of abnormal frogs (anything above 3 percent is considered unusual). Researchers are still uncertain about the cause of these malformations. In Vermont, four frog species (northern leopard, green, wood frogs, and bullfrog) and one toad (American toad) are documented with malformations, which have been observed in 53 towns and 13 counties. At Missisquoi Refuge, northern leopard and green frogs were sampled, and were found to have 0- to 10-percent rates of malformations. Table 3.11 summarizes those findings.

Table 3.11. Annual field survey results for malformed frogs on the refuge.

Year sampled	% malformations	# sites sampled	Species sampled
1999	1-2.5	3	northern leopard frog
2000	2.8-10.6	3	n. leopard frog & green frog
2001	0.9-1.2	2	n. leopard frog
2002	0-6.0	2	n. leopard frog
2003	0-5.6	3	n. leopard frog
2004	1.6-8	3	n. leopard frog

Invasive Species

Plants

The refuge has documented the following non-native invasive plant species on the refuge.

- Common reedgrass (*Phragmites australis*)
- Eurasian water milfoil (*Myriophyllum spicatum*)
- Purple loosestrife (*Lythrum salicaria*)
- Water chestnut (*Trapa natans*)
- Japanese knotweed (*Polygonum cuspadatum*)
- Reed canary grass (*Phalaris arundinacea*)

The refuge has monitored the distribution of purple loosestrife from 1985 to the present. Active control of purple loosestrife with herbicide was undertaken from 1985–1992. Individual clumps or areas of plants were spot-treated with backpack-mounted sprayers until the spraying was discontinued due to lack of funds and the development of biological control agents. Phytophagous insects, *Gallerucella* sp. beetles, and a weevil, *Hylobius transversovittatus*, were released in the mid-to-late 1990s, but no evidence indicates that those insects have become established. The flood regime where much of the purple loosestrife occurs is detrimental to the survival of the over-wintering eggs of the *Gallerucella* beetles. The *Hylobius* weevils were introduced once in stems of plants along the Maquam shoreline in 1996.

Common reedgrass occurs throughout the Champlain Valley wetlands. On the Missisquoi Refuge, a small population of the species—approximately 1 acre in size—first observed in 1986 growing in the Big Marsh Slough was sprayed with Rodeo™ glyphosate herbicide in 1988 by aerial application. The treatment was effective in killing that infestation. To date, common reedgrass has not reappeared at that site. We monitor it annually to detect any new growth that could originate from the seed bank where the plant was sprayed.

Eurasian water milfoil is common in the shallow waters of Missisquoi Bay. That exotic plant grows in association with native aquatic plants such as wild celery, coontail, and various species of pondweed (*Potamogeton* sp.).

Water chestnut is a serious pest plant in the southern end of Lake Champlain. A population of water chestnut located in Quebec is less than 10 miles from the refuge. If that invasive pest plant were to obtain a foothold in the northern end of Lake Champlain, it would cause a serious deterioration in wetland habitat quality as well as in the recreational utility of the lake. The first infestation of water chestnut on the refuge was documented in 2005 just north of the east branch of the Missisquoi River in a patch of hardstem bulrush.

A few patches of Japanese knotweed are found in the refuge. The refuge staff has attempted to control that species by applying an herbicide.

Animals

Zebra mussels and sea lamprey are two exotic invasive species of potential concern in the Missisquoi Bay area. Zebra mussels compete with native mussels for resources and habitat, and they suffocate native mussels by attaching to their shells. The refuge recently learned from the VT FWD that zebra mussels have been found in all of Lake Champlain including Missisquoi Bay. Although we have not discovered them on the refuge yet, it is likely they are here.

Lamprey populations are monitored throughout the Lake Champlain Basin. The number of lampreys detected by fisheries biologists in the Missisquoi River has not been sufficient to necessitate chemical treatment yet. Refuge staff will remain alert to the potential for those species to establish themselves in the Missisquoi River Delta.

Refuge Cultural and Historic Resources

Cultural resources are archaeological sites, sacred sites, historic structures, and museum property such as art, archaeological artifacts, and scientific collections. At Missisquoi Refuge, there are no historic structures or known sacred sites. However, artifact collecting and archaeological survey at the refuge has revealed 34 archaeological sites. The following information is based on our Archaeological Site Inventory files in the Northeast Regional Office.

As early as 1917, archaeologist Warren K. Moorehead, of the Peabody Museum and Phillips Academy at Andover, Massachusetts, and George Perkins, of UVM, used a motorboat to visit the “Missisquoi River Site” on the refuge. A local collector guided them to the prehistoric site, which they found stratified and at least 3 feet in depth (Moorehead 1922 in Chrisman 1981). Artifacts found during a revisit to the site in 1981 point to an occupation in the early Middle Woodland Period (A.D. 150–300), in the late Middle Woodland Period (A.D. 600–850) and perhaps again in the Late Woodland/Contact Period, when Native Americans began to take advantage of European tools (Chrisman 1981).

Later, during the mid-twentieth century, Vermont collector William Ross located many sites on refuge land, and reported their locations on site forms. Ross visited and reported at least seven of the refuge sites, relaying basic information about them, including summaries of artifacts found. Some of the sites he located on the refuge can be inferred to date to the broad Woodland Period, about 3,000 years ago to A.D. 1600, based on the triangular shape of the projectile points and the depth of the deposits.

In 1969, William Ritchie, New York State Archaeologist, conducted a survey on the refuge by boat. He visited several sites, and submitted a report containing their location information and a summary of the artifacts found.

Throughout the late twentieth century, construction projects such as the Cranberry Creek Dike exposed prehistoric archaeological sites on the refuge. In 1979, the Consulting Archaeology Program at UVM conducted the first modern, professional survey, in advance of a proposed expansion of the

Cranberry Creek Dike. They located a major Middle Woodland Period site that contained multiple focuses of prehistoric artifacts and activity, and included the historic archaeological remains of a house appearing on the 1796 map of the area. Avoiding that large a site would have been difficult, and the expansion was never undertaken. Based on the remains of a cooked bullhead, the Middle Woodland Period occupation was defined as A.D. 500–600, during a warm season.

In 1980, Kevin Chrisman, an archaeology student at UVM, undertook a review of then known sites in the Lower Missisquoi River Valley. He summarized known information, especially about William Ross' sites, and visited sites on the refuge, including Moorehead's "Missisquoi River Site", relocating them and reporting on their condition in a report in 1981.

Recently, a proposal to widen Vermont Route 78 as it crosses the refuge led to ongoing archaeological survey and excavation at two more large prehistoric sites and a historic archaeological site on the refuge. Currently 13 prehistoric sites are known for the refuge. They span the entire Woodland Period, and show the most intense use to have occurred during the Middle Woodland Period.

In addition to prehistoric archaeological sites, six historic archaeological sites have been located in the field. Three of those are not eligible for the National Register. One is eligible, and the rest have not been evaluated. The eligible site contains a record of the earliest European settlement by French, Dutch, and American farmers.

The site inventory for the refuge also contains 10 locations shown on historical maps (from 1916, 1871 and 1796) as containing houses or other structures. Those potential archaeological sites have not been confirmed in the field, but will be if they are threatened by any refuge activities.

Those mapped archaeological sites are not the only ones on the refuge. No systematic survey of the entire refuge has been done yet, and there are likely to be many more as yet undiscovered archaeological sites. The boundaries of the Missisquoi Refuge are thought to encompass a number of eighteenth century sites: for example, a fortified eighteenth century village of native people who used Missisquoi as a base for raiding the Connecticut River Valley in Massachusetts (Thomas and Robinson 1979). Gray Lock, likely a Woronoke Indian from Westfield, Massachusetts, led that group (Calloway 1990). In 1771, Simon Metcalfe received a grant of land at Missisquoi, and established a trading post at the mouth of the Missisquoi River (Calloway 1990), another location likely to be on the refuge.

To prevent destruction of yet undiscovered archaeological sites, the Regional Historic Preservation Officer reviews all ground-disturbing work on the refuge. Service archaeologists consult with the Vermont State Historic Preservation Office (the Division for Historic Preservation). Where needed, archaeologists will conduct or contract archaeological surveys. Projects are then designed to avoid sites, or some type of mitigation of the impacts can be adopted. Known sites are similarly avoided.

The refuge has 55,461 archaeological artifacts loaned for long-term curation to the University of Maine in Farmington, the Consulting Archaeology Program laboratory at UVM in Burlington, and in the Northeast Regional Office in Hadley, Massachusetts. The State of Vermont has no repository for archaeological items that meets Department of Interior standards for curating museum property. The U.S. Army Corps of Engineers has evaluated the condition of the Consulting Archaeology Program facility as "fair." In addition,

the refuge has art, botanical and zoological museum property at its headquarters in Swanton.

Refuge Public Use

Public use of the refuge is high and climbing. We recorded nearly 35,000 visits in FY 2004. The six priority public uses for national wildlife refuges—hunting, fishing, wildlife observation and photography, and environmental education and interpretation—are all popular on the Missisquoi Refuge.

Hunting

Hunting, a traditional and popular outdoor activity, is permitted on portions of the refuge in accordance with state and federal seasons and regulations. Special arrangements to accommodate persons with disabilities can be made by contacting the refuge manager. The refuge provides waterfowl, big game, and upland game hunting opportunities. Their details are included in these refuge brochures: Migratory Game Bird Hunting Map and Regulations and 2005 Upland Game/Big Game Hunting Map, Regulations and Permit. We update them periodically as we evaluate the hunt programs each year. The conditions presented here are for 2005, and additional regulations usually apply as noted in the refuge brochures. See also maps 2–4 and 2–5 for the location of hunt areas. Guiding and other commercial hunting services require a special use permit from the refuge manager.

The refuge charges an annual \$10 fee for an upland game/big hunting permit. Waterfowl hunters that draw a hunting blind site during a pre-season lottery pay a \$10 permit fee.

Waterfowl Hunting

Mallard, wood duck, ring-necked duck, American black duck, blue-winged teal, and American wigeon are most of the waterfowl harvested on the refuge. Waterfowl hunting areas are generally accessed using watercraft, but some are accessible on foot.

In some areas, the refuge legal boundary extends beyond the shoreline. Hunters are required to place blinds outside of posted signs providing improved hunting opportunities while protecting important feeding, resting, and cover habitat for migratory birds. All persons hunting migratory birds on the refuge must hold a valid Federal Migratory Bird Conservation Stamp, Vermont State Duck Stamp, a Vermont State hunting license and be registered with the federal Harvest Information Program (HIP). Retrievers are required for hunting waterfowl in the following areas: Maquam Swamp Area, Long Marsh Channel/Metcalf Island, and Saxs Pothole/Creek and Shad Island Pothole.



Vermont Fish & Wildlife Department

Waterfowl Hunting

For the hunting of geese, brant, ducks, mergansers and coots, the refuge is divided into six discrete waterfowl hunting units: three public hunting areas (Delta Lakeshore, Maquam Swamp, Maquam Shore) and three controlled hunting areas (Saxe's Pothole Creek and Shad Island Area, Junior Waterfowl Hunting Area (including Long Marsh Bay, Patrick Marsh and Charcoal Creek), and the Long Marsh Channel and Metcalfe Island Area (map 2–5).

No refuge permits or fees are required to hunt in public hunting areas. Blind staking, permanent blinds, and unattended decoys are prohibited in those areas.

Some conditions apply to specific public hunting areas as follows.

Delta Lakeshore Area—This hunting unit includes lakeshore areas from Shad Island to the south side of Martindale Point but does not include Saxes Pothole/Creek and Shad Island Pothole. Jump shooting is not allowed within 200 yards of a party hunting from a boat or blind.

Maquam Swamp Area—This hunting area encompasses about 200 acres west of the Central Vermont Railroad and south of the private in-holding and is open to migratory bird hunting with the following special requirements: Jump shooting is allowed. Each party of hunters (up to two people) must have a retriever. No hunting is allowed within the area encompassing the old headquarters nature trail. This area is identified with “No Hunting Zone” signs.

Maquam Shore Area—This hunting unit encompasses a 30-acre area along the lakeshore of Maquam Bay and is bounded by private land on the west and a Vermont WMA on the east. Jump shooting is not allowed within 200 yards of a party hunting from a boat or blind.

All hunting in a controlled hunting area requires a refuge permit. Permits for the first two weeks of the season are obtained through a preseason lottery. Successful permittees are issued a non-transferable permit for a specific date and waterfowl hunting blind site for a \$10 fee. Thereafter, permits are available daily on a first-come, first-served basis, at no charge. There is no charge for permits issued on the day of the hunt. Blind areas yield highly variable harvests due to annual changes in water levels in these units. During low water years, these areas are not very productive as hunting units, while higher water levels generally produce better hunting opportunities for a longer period.

All waterfowl hunters are required to sign in and out of their sites by completing the sign in, sign out sheet for their hunt area. Permanent blinds and unattended decoys are prohibited. Jump shooting is not allowed.

Some conditions apply to specific controlled hunting areas, as follows.

Saxe’s Pothole/Creek and Shad Island Pothole

This hunting unit encompasses Saxe’s Pothole/Creek and Shad Island Pothole. Five sites, numbered 1–5, are staked and available to five hunting parties in Saxe’s Pothole, one site, numbered 6, is staked and available to one hunting party in Shad Island Pothole. A boat is required to access each of these blind sites and each hunting party is required to use a retriever. Shooting hours will be one-half hour before sunrise to sunset.

Junior Waterfowl Hunting Area

This controlled hunting area encompasses Long Marsh Bay, Patrick Marsh and that portion of Charcoal Creek south of Vermont Route 78. Eleven blind sites are established for use by Junior Waterfowl Hunters: blind sites 4–8 in Long Marsh Bay, blind sites C–F in Charcoal Creek, and blind sites A–B in Patrick Marsh. A small flat bottom boat, car top boat, or canoe is necessary for access to Charcoal Creek and Patrick Marsh blind sites. Access is available at the Charcoal Creek crossing on Vermont Route 78 or from a pull off on Route 78 about three-quarters of a mile east of the Charcoal Creek access. Shooting hours are one-half hour before sunrise to 11:00 AM. Junior Waterfowl Hunters (ages 12–15, inclusive,

at the time of the hunt), following successful completion of the annual Refuge training program (usually held the third or fourth Saturday in August), via for blind site assignments during a lottery drawing at the conclusion of the training. The eleven blind sites are available exclusively to these Junior Waterfowl Hunters the first four Saturdays and Sundays of the duck season.

Only Junior Hunters may discharge a firearm in this area during the Junior Hunt periods. Each party must use at least six decoys. Hunting is permitted, and recommended, from portable blinds and boat blinds constructed and placed by the refuge for the Junior Waterfowl Hunting program at some of the blind sites. Stationary blinds may be constructed and left in place for the duration of the season by Junior Hunters with the refuge manager's approval. Otherwise, permanent blinds are not permitted. Junior Waterfowl Hunting Area is available only to current-year, refuge-trained Junior Waterfowl Hunters during the Youth Waterfowl Hunting Weekend in late September.

Long Marsh Channel and Metcalfe Island

This controlled hunting area encompasses the Metcalfe Island Pothole and Long Marsh Channel. Three blind sites, designated 1–3 are established in Long Marsh Channel. Three blind sites, designated 8–10, are established on Metcalfe Island. A boat is required to hunt at each of these blind sites. Shooting hours are one-half hour before sunrise to 11:00 a.m. Hunting is limited to Tuesdays, Thursdays, and Saturdays throughout the waterfowl hunting season for ducks. Permits for the first five days of the duck season are obtained through application to a pre-season lottery. Following the first five days, hunters may acquire permits on a first-come, first-served basis with self-service permitting and sign in at the Mac's Bend Landing, no more than two hours before legal shooting time. A hunting party must use at least six decoys and is required to use a retriever.

Other Migratory Birds

The refuge is open to hunting for woodcock and common snipe in two areas:

Delta Lakeshore Area, excluding the Saxe's Creek/Pothole and Shad Island Pothole controlled hunting areas.

Maquam Swamp Area, however, each hunting party must have a retriever. No permit is required to hunt woodcock and snipe in those areas.

Upland Game/Big Game Hunting

Upland game (gray squirrel, eastern cottontail, snowshoe hare, and ruffed grouse) and big game hunting is permitted on portions of the Missisquoi Refuge during certain seasons. White-tailed deer is the only big game species legally hunted, and may be harvested using bow and arrow, shotgun, muzzleloader, and rifle on designated sections of the refuge. All upland and big game hunters must register, fill out a permit, and remit \$10.00 prior to hunting. Hunters may not enter closed areas of the refuge for any reason, except for the recovery of legally harvested animals with the consent of a refuge employee, and in that case may not carry a weapon. Only shotguns, muzzleloaders, or archery equipment may be used on open areas east and north of Vermont Route 78. Rifles may not be used in those areas at any time (map 2-4).

All hunters during the State regular firearms season, Youth Deer Hunting Weekend, and muzzleloader deer hunt must wear in a conspicuous manner on head, chest and back a minimum of 400 square inches of solid-colored hunter orange clothing or material. Permanent tree stands and ground blinds are prohibited. Temporary, portable tree stands and ground blinds in accordance with state regulations are acceptable. A written notation from the refuge

manager is required on the big game permit prior to leaving a temporary stand or blind unattended. Artificial light (“spotlighting”) to locate wildlife and baiting or hunting over bait, salt or any attractant are prohibited on the refuge. Dogs are allowed for hunting migratory game birds, cottontail rabbit, snowshoe hare, and ruffed grouse during designated seasons only.

Fishing

Fishing, one of the most popular public use activities on the refuge, is enjoyed by all ages throughout the year. Fishing accounts for a large part of the visitor activity each year, especially in the summer and early fall: 13,830 refuge visitors took advantage of fishing opportunities in 2004. The refuge works to enhance fishing opportunities by permitting fishing according to state regulations and maintaining appropriate facilities (map 2-6).

Approximately 2 miles of trails are maintained to facilitate pedestrian access to fishing, and an additional 1-mile gravel road from Louie’s Landing to Mac’s Bend is open to public vehicle travel from September–November and pedestrian use year-round. Boats and canoes may be launched from Louie’s Landing all season, while a second boat ramp, at Mac’s Bend, is open from September to November. The Louie’s Landing area has designated fishing access available for disabled individuals, one wide boat ramp for small boats, two vault toilets, a public parking area, and an interpretive kiosk. The Mac’s Bend Boat Launch site provides two narrow boat ramps, a seasonal waterfowl hunt program kiosk, a public parking area, and access to the 2½-mile Long Marsh jeep trail, which follows along the river to Missisquoi Bay.

The fishing public enjoys the great variety of fish that abound in refuge waters. The most sought-after fish species include walleye, northern pike, largemouth bass, bullhead, yellow perch, and crappie. Other species that are caught include white perch, chain pickerel, muskellunge, sheepshead (drum), gar, pumpkinseed, smallmouth bass, rock bass, bowfin, catfish, carp and white and red suckers. Both live and artificial bait are used to catch these fish. Weather conditions, water conditions, and season all play a role in the process of selecting the right kind of bait to successfully catch fish in the warm, shallow waters in and around the refuge.

Everyone who fishes on the refuge must respect regulations put in place to protect its biological resources. All fishing requires a valid state fishing license, and is permitted according to state regulations. Sport fishing on the refuge follows the fishing regulations established by the VT FWD. Those regulations are published annually in the Annual Guide to Hunting, Fishing and Trapping Laws, which is available at refuge headquarters.



Fisherman at Louie’s Landing

To protect wildlife and visitors, camping, open fires, cutting firewood, littering, and leaving vehicles overnight are prohibited and subject to state and federal prosecution. Bank fishing is permitted only along Charcoal Creek where it passes under Route 78, and along the shoreline of the Missisquoi River from just west of the refuge headquarters to Mac’s Bend boat launch site, and is accessible only on foot from Louie’s Landing to the Mac’s Bend launch site. We ask the public to observe and respect “Closed Area” signs posted from April—November in order to provide undisturbed nesting and resting areas for endangered osprey, threatened black tern, and the great blue heron rookery in the delta and adjacent marsh units.

As lost and discarded lead sinkers have been responsible for the death of more than half of the loons found dead in Vermont, the refuge also suggests that anglers protect loons and other wildlife by switching to non-toxic sinkers made of bismuth, tin, steel, tungsten, and high-density resin putty. Discarded monofilament fishing line is also harmful to a variety of fish and aquatic birds. For that reason, we ask the fishing public to recycle or responsibly place unneeded fishing line in the trash. It is noteworthy that in 2005, Vermont enacted a law making the sale of sinkers containing lead illegal in 2006, and the use of lead sinkers illegal in 2007.

We also ask anglers to help prevent the spread of nuisance aquatic species when moving between bodies of water. Boaters traveling between water bodies can inadvertently spread invasive species not native to Vermont. Once introduced, they often grow unchecked, quickly out-competing native species for available nutrients and space and, eventually, replacing native plants or animals completely. To avoid the disruption of aquatic communities, we ask those who fish on the refuge to remove all vegetation attached to boats or trailers; rinse their boats and equipment with hot water and dry them for five days in the sun; learn to recognize nuisance aquatic species; and not discard live bait into Lake Champlain. The refuge promotes fishing as a priority public use, and responsible fishing ethics and adherence to refuge regulations will ensure the fishing public of all ages continued enjoyment of this recreational opportunity.

**Wildlife Observation
and Photography,
Interpretation,
and Environmental
Education**

Wildlife observation, photography, environmental education, and interpretation are all refuge priority public use activities. The refuge facilitates them. In 2004, refuge staff and volunteers conducted 40 refuge tours and walks, including bird walks, owl prowls, winter ecology bog walks, boat tours, canoe tours, and woodcock walks, among others.

The Black Creek and Maquam Creek interpretive trails provide good opportunities for waterfowl and wading bird observation and photography, as the trails pass through 1½ miles of wooded lowland. River mud shorelines are also an excellent place to find animal tracks. A self-guiding trail guide is available in the refuge leaflet box located at the trailhead.

Visitors may also observe wildlife by walking alongside the Missisquoi River on the 1-mile Mac's Bend Road from Louie's Landing to Mac's Bend. The Mac's Bend Boat Launch site provides access to the 2½-mile Long Marsh jeep trail that follows along the river toward Missisquoi Bay. Two additional trails can be accessed on Tabor Road from the Old Railroad Passage parking area. The ½-mile Old Railroad Passage Trail passes through the southern corner of Maquam Bog and ends at Maquam Bay. The abandoned railroad bed from Tabor Road to Maquam Bay is owned by the Vermont Fish and Wildlife, but is used for refuge wildlife and habitat surveys and by refuge visitors. Another ½-mile trail starts from the parking area and crosses Tabor Road, where it forks: one mowed path leads to an observation platform overlooking the Stephen J. Young Marsh; the other goes around the edge of the marsh and behind the marsh into an area of managed woodcock cuts. At the Tabor Road Overlook parking area, visitors can enjoy a view of the refuge grasslands and a small wetland area, and learn about food webs from an interpretive sign placed at the site. Visitors often gather here to view deer in the fields.

The refuge provides environmental education to area students. In 2004, 872 students visited the refuge. Most school groups are elementary and middle school visitors who use the refuge to augment classroom work related to the environment. An additional 1,400 students were taught offsite at school conservation days, in classroom programs, and at Earth Day Celebrations.

The majority of refuge visitors come during the summer and fall months to take advantage of favorable trail and opportunities for viewing wildlife and the brilliance of Vermont fall foliage. Refuge trails and roads are used some during the winter, when snow conditions are conducive to cross-country skiing or snowshoeing. The number of people canoeing and kayaking on the quiet, slow-flowing Missisquoi River has gradually increased over the past 10 to 15 years. Blueberry picking and hiking are also popular visitor activities.

Activities Not Allowed on Missisquoi Refuge

Snowmobiling, all-terrain vehicle (ATV) use, and biking on trails are among the activities not allowed on refuge land. Walking dogs off a leash, picking fiddleheads and other plants, camping, and campfires are also prohibited. Trespassing in closed areas is illegal, whatever the purpose.

Finding of Appropriateness of a Refuge Use

With the exception of 1) Six wildlife-dependent recreational uses (hunting, fishing, wildlife observation and photography, and environmental education and interpretation) and 2) Take of fish and wildlife under State regulations, which have been administratively determined to be appropriate, refuge managers must decide if all proposed and existing uses on the refuge are appropriate uses by writing a Finding of Appropriateness of a Refuge Use. If an existing use is not appropriate, the refuge manager will eliminate or modify the use as expeditiously as practicable. If a new use is not appropriate, the refuge manager will deny the use without determining compatibility. The Appropriate Refuge Uses policy clarifies and expands on the compatibility policy, which describes when refuge managers should deny a proposed use without determining compatibility. When refuge managers find a use is appropriate, the use then must be determined to be compatible before it is allowed on the refuge. Table 3.12 lists the uses for which Finding of Appropriateness of a Refuge Use was done. See appendix B for the full Finding of Appropriateness of a Refuge Use documents.

Table 3.12. Finding of Appropriateness of Refuge Uses

Refuge Use	Appropriate	Not Appropriate
Snowmobiling		X
Access for Commercial Bait Collecting	X	
Berry Picking	X	
Bicycling		X
Dog Walking		X
Motorized boating to facilitate priority public uses	X	
Non-motorized boating to facilitate priority public uses	X	
Research conducted by non-refuge personnel	X	

Compatibility Determinations

Refuge managers must determine if each public use is compatible with the purposes for which the refuge was established by writing a compatibility determination. Public uses on national wildlife refuges fall in two categories: priority uses and secondary uses. Priority uses, as defined by Congress, include hunting, fishing, wildlife observation and photography, and environmental education and interpretation. All other public uses on a refuge are considered secondary uses. Priority public uses are reviewed every 15 years, and all secondary public uses are reviewed every 10 years. Table 3.13 lists the activities determined to be compatible while table 3.14 lists the activities that are not compatible on the refuge. See appendix B for the full compatibility determination documents.

Table 3.13. List of activities that have been determined compatible on the refuge.

Compatibility Determination	Priority Uses	Secondary Uses
Berry Picking		X
Research by non-refuge personnel		X
Access for Commercial Bait Collecting (Commercial Fishing)		X
Motorized Boating		X
Non-Motorized Boating		X
Oral vaccination by aerial baiting to control raccoon variant of the rabies virus	X	
Environmental Education	X	
Wildlife Observation	X	
Photography	X	
Walking/Hiking, Cross Country Skiing on the Nature Trail		X
Hunting Access to Adjacent Public Private or State Land		X
Upland Small Game Hunting	X	
Other Migratory Bird Hunting	X	
Waterfowl Hunting	X	
Big Game Hunting (White-tailed Deer)	X	
Recreational Fishing	X	
Furbearer Management		X
Commercially Guided Tours		X
Commercially Guided Waterfowl Hunting		X

Table 3.14. List of activities that have been determined NOT compatible or under consideration for the refuge.

Compatibility Determination	Determination Date	Wildlife-dependent	Not wildlife-dependent
Bicycling	2005		X
Snowmobiling	2005		X

