Chapter 3: Refuge Environment and Management

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3.1 Geographic/Ecosystem Setting

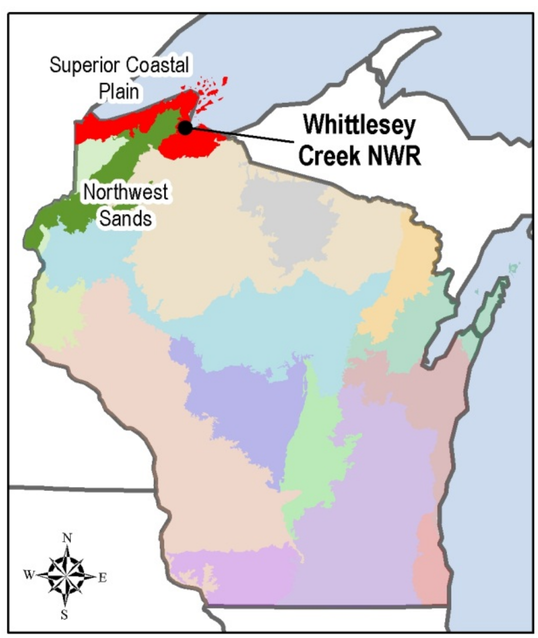
Whittlesey Creek National Wildlife Refuge (NWR, Refuge) is located along the south shore of Lake Superior near the head of Chequamegon Bay in Bayfield County near Ashland, WI. Lake Superior is the largest freshwater lake, by surface area, in the world. The mouth of Whittlesey Creek is associated with a large coastal wetland and floodplain complex that extends along the south shore of Chequamegon Bay.

Laurentian Mixed Forest

The Refuge is within the Laurentian Mixed Forest province as defined by Bailey's ecological classification system developed by the U.S. Forest Service (USFS). The Laurentian Mixed Forest province covers an extensive area along the Great Lakes and New England lowlands. Most of the province has low relief, but rolling hills occur in many places. Elevations range from sea level to 2,400 feet. Glacial features are typical of the area. This province lies between the boreal forest and the broadleaf deciduous forest and is therefore transitional. Some locations consist of mixed stands of a few coniferous and deciduous species; others are pure deciduous forest or pure coniferous forest (Bailey, 1976; Bailey, 1980).

Wisconsin Ecological Landscapes

Figure 3-1: Wisconsin Ecological Landscapes



The Wisconsin Department of Natural Resources (WDNR) has adopted a classification system that divides the state into 16 ecologically similar regions called Ecological Landscapes.

The Refuge lies within the Superior Coastal Plain, which is the northernmost Ecological Landscape (Figure 3-1). The major landform is a nearly level plain of lacustrine clays that slopes gently northward toward Lake Superior. The clay plain is separated into two segments by the more rugged Bayfield Peninsula. The mouths of many of the streams entering Lake Superior are submerged, creating freshwater estuaries. Historically, the Superior Coastal Plain was almost entirely forested with a distinctive mixture of white pine, white spruce, balsam fir, paper birch, balsam poplar, trembling aspen, and white cedar occurred on the lacustrine clays. The present-day clay plain forest has been fragmented by agricultural use, and approximately one-third of this Ecological Landscape is now non-forested. Older forest successional stages are now rare (WDNR, 2012).

More than half of the upstream watershed (easement acquisition area) lies within the Northwest Sands Ecological Landscape. The Northwest Sands is a large glacial outwash system containing two major landforms: flat plains or terraces along glacial meltwater channels, and pitted or “collapsed” out wash plains containing kettle lakes. Soils are deep sands, low in organic matter and nutrients. Historic vegetation was dominated by jack pine and scrub oak forest and barrens. White and red pine forests were also a sizable component of the area. Current vegetation is a mix of forest, agriculture, and grassland with some wetlands in the river valleys. Approximately 64 percent of the area is classified as timberland, of which 49 percent is under public ownership. Groundwater conditions are among the least polluted and most vulnerable in the state.

Other Conservation Lands

(See Figure 3-2.)

U.S. Forest Service

The former Chequamegon and Nicolet National Forests, established in the early 1930s, were combined into the Chequamegon-Nicolet National Forest in 1998, but each national forest has retained its individual identity. The Chequamegon side of the forest covers more than 850,000 acres in Ashland, Bayfield, Sawyer, Price, Taylor, and Vilas counties. About three-quarters of the Whittlesey Creek drainage basin is within the Washburn Ranger District of this national forest.

Northern Great Lakes Visitor Center

The Northern Great Lakes Visitor Center (NGLVC, Visitor Center, Center) is adjacent to the southern boundary of the Refuge on a 180-acre tract owned by the USFS. The land includes black ash swamp, sedge meadow, mature cedar and tamarack forest, restored wetlands, and other parts of the tract are managed as hayfield. NGLVC land also includes an experimental agroforestry area and a snowmobile trail.

National Park Service

The Apostle Islands archipelago includes 22 islands off the Bayfield Peninsula. The Apostle Islands National Lakeshore, a unit of the National Park System, encompasses about 42,000 acres of land, including 21 of the islands plus a 12-mile segment of shoreline on the peninsula. Most of the National Lakeshore is covered with unbroken mature second growth forest. The area is at the continental northwestern limits of the hemlock-white-pine-northern hardwood forest and contains elements of boreal forest.

Bad River Band of Lake Superior Chippewa

The 16,000-acre Kakagon and Bad River Sloughs complex is the largest undeveloped coastal wetland complex on the upper Great Lakes. Located east of Ashland on land owned by the Bad River Band of Lake Superior Chippewa, it is home to a variety of natural plant communities and is often called the "Everglades of the North." The Kakagon and Bad River Sloughs complex provides important spawning and nursery areas for fish and stopover habitat for migratory birds and is the only remaining location where wild rice is abundant on Lake Superior.

This coastal wetland ecosystem is among the richest and most extensive of its kind and has received many conservation designations: National Park Service National Natural Landmark, Nature Conservancy Priority Conservation Area, Wisconsin Land Legacy Place, Wisconsin Bird Conservation Initiative Important Bird Area, Wisconsin Wetlands Association Wetland GEM, and Wisconsin Coastal Wetland Primary Inventory Site. Most recently, the Kakagon and Bad River Sloughs complex was recognized in 2012 as a Wetland of International Importance, or Ramsar site—the first to be owned by a tribe.

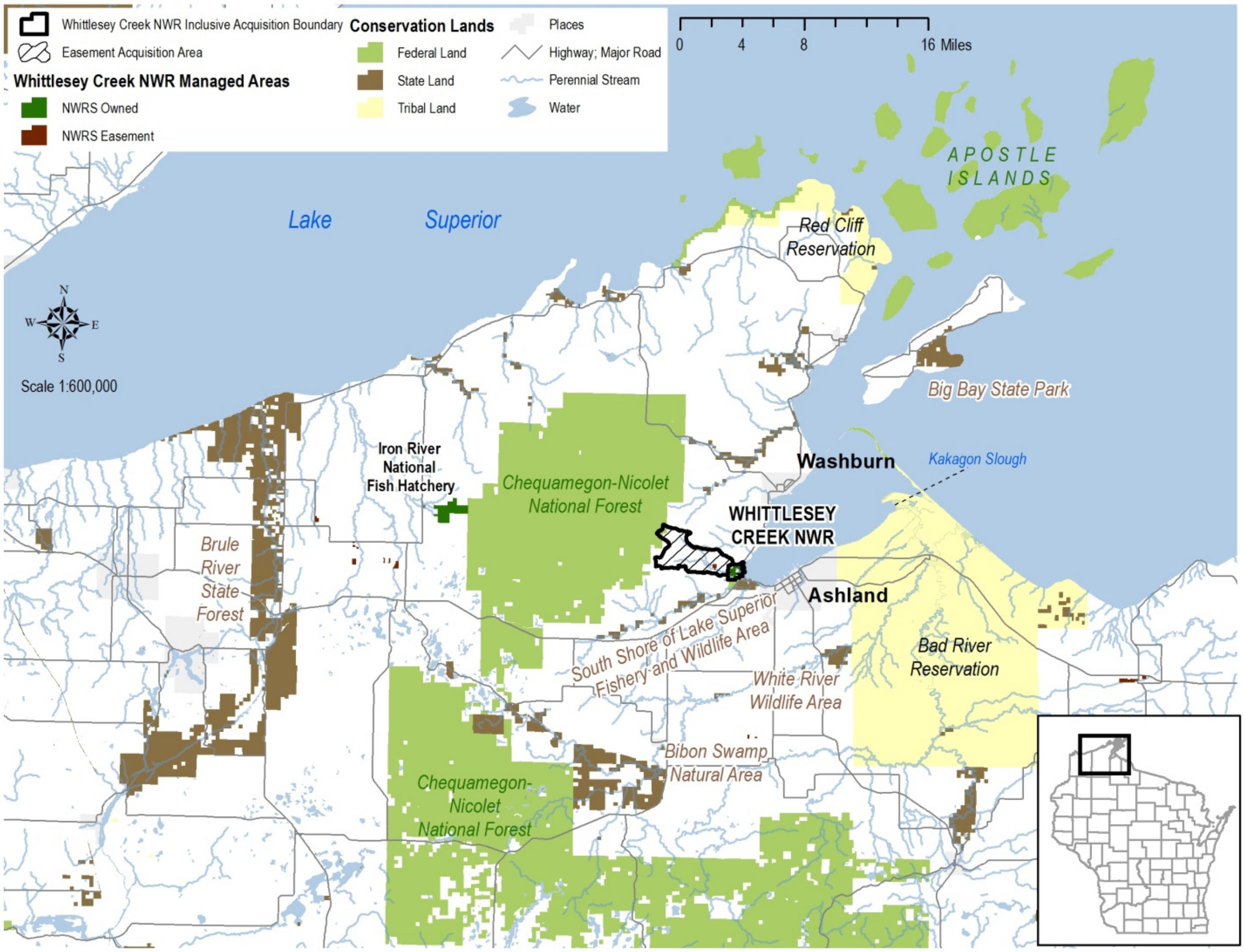
Wisconsin Department of Natural Resources

The South Shore of Lake Superior Fishery and Wildlife Area includes various properties owned and managed by the WDNR along the streams and shores of Lake Superior in Bayfield County. The goal is to enhance stream and coastal habitat to benefit flora and fauna associated with these specific areas, and to provide public recreation and education opportunities. The project spans five stream drainages and their associated coastal wetlands. Units include Fish Creek Sloughs (250 acres), Cranberry River Mouth (35 acres), Flag River (600 acres), Big Sioux River (487 acres), and Pikes Creek Slough (40 acres). WDNR owns more than 250 additional acres adjacent to the Fishery and Wildlife Area. The WDNR property borders the Refuge and includes coastal wetlands along Chequamegon Bay at the mouth of Fish Creek.

City of Ashland

Ashland’s 100-acre Prentice Park includes wetlands and boreal forest that are popular for wildlife viewing.

Figure 3-2: Other Conservation Lands



3.2 Physical Environment

Geology

The Lake Superior basin emerged from glacial cover between 13,000 and 9,000 years ago. During that time, ice melt formed pro-glacial lakes of changing configuration and drainage patterns. Lake Superior lies along the southern edge of the Canadian Shield, a region of complex geological history dominated by granite and sandstone overlain by glacial till. The red lacustrine clay soil underlying Whittlesey Creek and adjoining watersheds is a result of deposition that occurred when the level of Lake Superior was considerably higher than today (U.S. Fish and Wildlife Service [FWS, Service], 1998).

Three main geologic features define the Whittlesey Creek watershed—Bayfield Group, Copper Falls Formation and Miller Creek Formation. The Bayfield Group is Precambrian bedrock, consisting mostly of sandstone, siltstone, and locally abundant shale and conglomerate. The Bayfield Group is overlain by the Copper Falls Formation of sandy till that is up to several hundred feet thick. It is thickest along the central spine of the Bayfield peninsula and thins toward Lake Superior. The Miller Creek Formation overlies the Copper Falls Formation and Bayfield Group up to about 1,100 feet above sea level (500 feet above Lake Superior). It is dominated by glacial lake clay deposits, although some areas have layers of sandy relict shoreline (Lenz et al., 2003).

Topography

The topography of the watershed is relatively flat in the lake plain near Lake Superior, but steeper upstream, increasing in elevation from about 600 feet to about 1,200 feet in less than 10 miles. The hills are rolling except for the confined stream and tributary valleys, which are very steep in the upper and middle section of the watershed. The slopes flatten out considerably about one-half mile west of the western Refuge boundary. Floodplains that connect Little Whittlesey, Whittlesey, and Terwilliger Creeks are relatively level with a gentle slope toward Lake Superior and a 20-foot elevation drop over one mile (FWS, 2006c).

Soils

Soils below about 1,100 feet above sea level (500 feet above Lake Superior) within the watershed are mostly formed in clays originating from the post-glacial lakebed of Lake Superior. Surface drainage features become evident at elevations below 1,100 feet because the red clay soils have very low infiltration rates. Runoff from the uplands quickly enters gullies, ravines, and streams, especially in the steeper, upper portions of the watershed. Alluvial fine sands are also common, being deposited in floodplains from past and present overbank floods.

Till plain and lake plain (upland) soils cover roughly one-third of the Refuge. These soils are characteristically clay loams, silt loams, or sandy loams and are predominant throughout the watershed. Poor internal drainage produces intermittently saturated conditions on the clay loams. Sandy and loamy alluvial floodplain soils cover about two-thirds of the Refuge, but are less common across the watershed. Localized areas of peat and muck are associated with springs and saturated depressions (FWS, 2006c).

Hydrology

Whittlesey Creek NWR is located along Chequamegon Bay on the south shore of Lake Superior. The surface area of the upland Lake Superior watershed is smaller than the lake itself, resulting in very short drainage systems into the lake. The coastal areas of Chequamegon Bay include the largest and most significant wetlands in the Lake Superior basin.

Chequamegon Bay.

Three streams flow through the Refuge and empty into Chequamegon Bay: Whittlesey Creek, Little Whittlesey Creek, and Terwilliger Creek. All three are spring-fed and flow year round. All three have been altered from historic conditions by erosion, sediment, channelization, and loss of large woody debris.

Lake Superior and Chequamegon Bay

The overall water level in Lake Superior has been controlled by the International Joint Commission through the Great Lakes lock and dam system since 1921, although Lake Superior water has been kept relatively stable since 1973. Water levels vary frequently, however, due to rainfall and snowmelt, annual hydrologic cycles, and natural surface water oscillations called seiches. In addition, the bottom of Lake Superior continues to rebound from the weight of past glaciers (isostatic rebound), raising the water level relative to land by about one foot per century.

The Refuge is part of a large complex of coastal wetlands and streams at the head of Chequamegon Bay. This complex is critical to the health of the Bay and its economically important fishery. Water level fluctuations in the Bay affect coastal wetland function, vegetation composition, stream flow, and sediment loading. Isostatic rebound has inundated the mouths of Whittlesey Creek and Fish Creek.

Whittlesey Creek

Whittlesey Creek.

Whittlesey Creek is the largest stream on the Refuge. Consistent groundwater input results in relatively stable water temperatures and year round flow beginning approximately one-half mile upstream of the North Fork confluence. Whittlesey Creek is listed by the WDNR as a Class I trout stream indicating sufficient natural reproduction to sustain populations at or near carrying capacity with no stocking of hatchery trout. Water quality is good (Stromberg, 2012). Whittlesey Creek sometimes carries a heavy load of sand and silt. The silt and fine sand are usually carried out to Lake Superior while the coarser sand is deposited in the stream, degrading habitat. The channel slope flattens considerably near the mouth at Lake Superior. The North Fork of Whittlesey Creek has an average slope of 0.02, whereas the average slope of Whittlesey Creek below the confluence with the North Fork is 0.005 (Lenz et al., 2003).

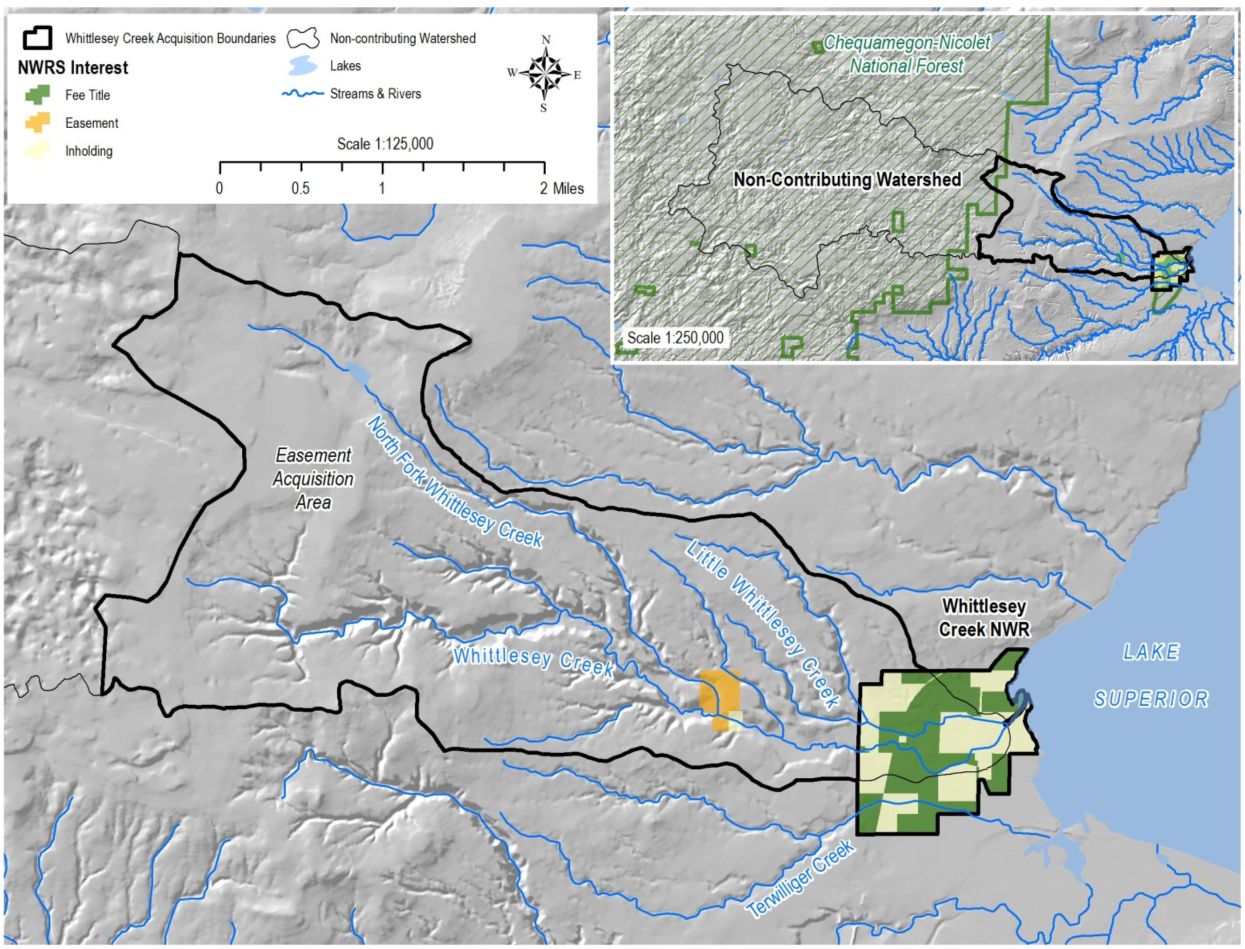
Following significant floods in the 1940s, the U.S. Army Corps of Engineers (USACE) dredged the lower 4,500 feet of Whittlesey Creek, removed the meanders, and redirected the flow straight east into Lake Superior from Highway 13 in an effort to dewater and stabilize the floodplain. The Red Clay Interagency Committee redirected the channel to its present location in 1958 because sand deposits had filled the previous dredging. Their report noted that the new channel lowered the water level in the floodplain by 30 inches (Red Clay Interagency Committee, 1960). Another result of these activities was a straight shallow stretch of stream lacking significant habitat diversity.

The Red Clay Interagency Committee initiated watershed improvements in the 1950s to reduce flows, erosion, and sedimentation from stream banks, road ditches, and farm fields. Projects included fencing livestock away from streams, vegetating stream banks and road ditches, constructing farm ponds, and planting trees. In 1991, Whittlesey Creek was designated a “priority watershed” under the Wisconsin Nonpoint Source Pollution Abatement Program. The 1996 management plan identified strategies to improve the watershed health of Whittlesey Creek and supported partnership efforts to protect and improve fish habitat (WDNR, 1996). Special funding was available for 10 years to provide local landowner assistance and to demonstrate best management practices to reduce upland runoff, stabilize stream banks, and enhance in-stream habitat.

Whittlesey Creek Basin

The Whittlesey Creek drainage basin, as delineated based on topography, covers about 24,000 acres, but only about 4,700 acres of the Whittlesey Creek drainage basin contribute surface water to Whittlesey Creek (Figure 3-3).

Figure 3-3: Watershed, Streams, Topography



The non-contributing portion of the basin is in the Bayfield Highlands and is composed of sandy deposits with no surface drainage features. This non-contributing basin does not contribute surface water or groundwater to Whittlesey Creek (Lenz et al., 2003). Nearly the entire non-contributing basin is located within the Chequamegon-Nicolet National Forest.

The 4,700-acre surface-water-contributing area includes Whittlesey Creek, the North Fork, and numerous small tributaries. This is the area commonly referred to as the Whittlesey Creek watershed. The upper reaches generally have sloping plains in the uplands and deeply incised valleys. The elevation changes from 1,100 feet mean sea level (msl) at the upper end, to about 600 feet msl at Lake Superior. Because the Refuge is located at the mouth of Whittlesey Creek, stewardship of upstream watershed lands directly and indirectly affects Refuge lands.

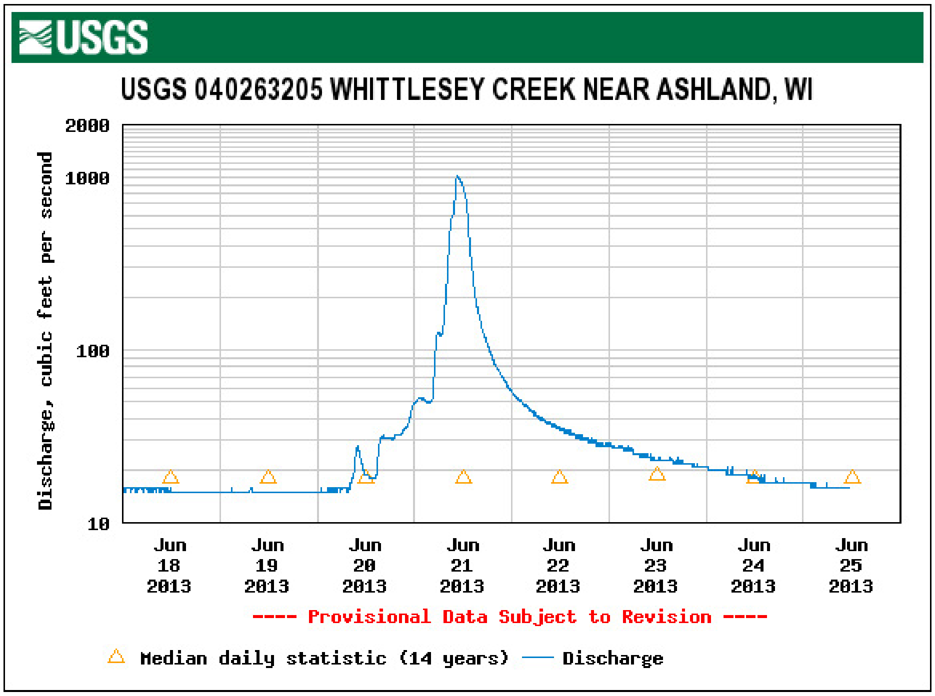
Unflooded section of Whittlesey Creek on the Refuge.

Flooded section of Whittlesey Creek on the Refuge.

Surface water generally moves as sheet flow until reaching a ditch or gully leading to the stream channel network. The gullies and channels are generally steeply sloped, so water passes rapidly through the basin. Soils of the surface-water-contributing basin are dominated by red clays that give water little chance to infiltrate. Land cover and infrastructure changes have altered historic surface water patterns, redirecting overland flow, increasing flood power, destabilizing stream banks, and increasing sediment load. The result is a very flashy stream that peaks quickly within 24 hours of a large rainfall or snowmelt. Base flow in Whittlesey Creek is a consistent 17 to 18 cubic feet per second (cfs), with flood peaks of over 500 cfs. On June 21, 2013, a record 1,010 cfs peak was observed at the gaging station near the mouth following unusually heavy rains on saturated soils.

Modeling results indicate that changes in land cover in the surface-water-contributing basin would have minimal effects on average annual runoff, but would affect Whittlesey Creek flood peaks (Figure 3-4). Converting the entire surface-water-contributing basin to forested land cover would reduce 100-year flood peaks by 12 to 14 percent, potentially reducing sedimentation on the Refuge. If the basin were developed into 25 percent residential land or returned to the intensive agriculture of the 1920s, flood peaks would increase by up to 12 and 18 percent, respectively (Lenz et al., 2003).

Figure 3-4: Hydrograph



Whittlesey Creek Groundwater

Water flow on the Bayfield Peninsula is defined by the three main geologic features: Bayfield Group, Copper Falls Formation, and Miller Creek Formation (see Geology section, earlier in this chapter). These features have resulted in two groundwater systems: deep flow and shallow flow.

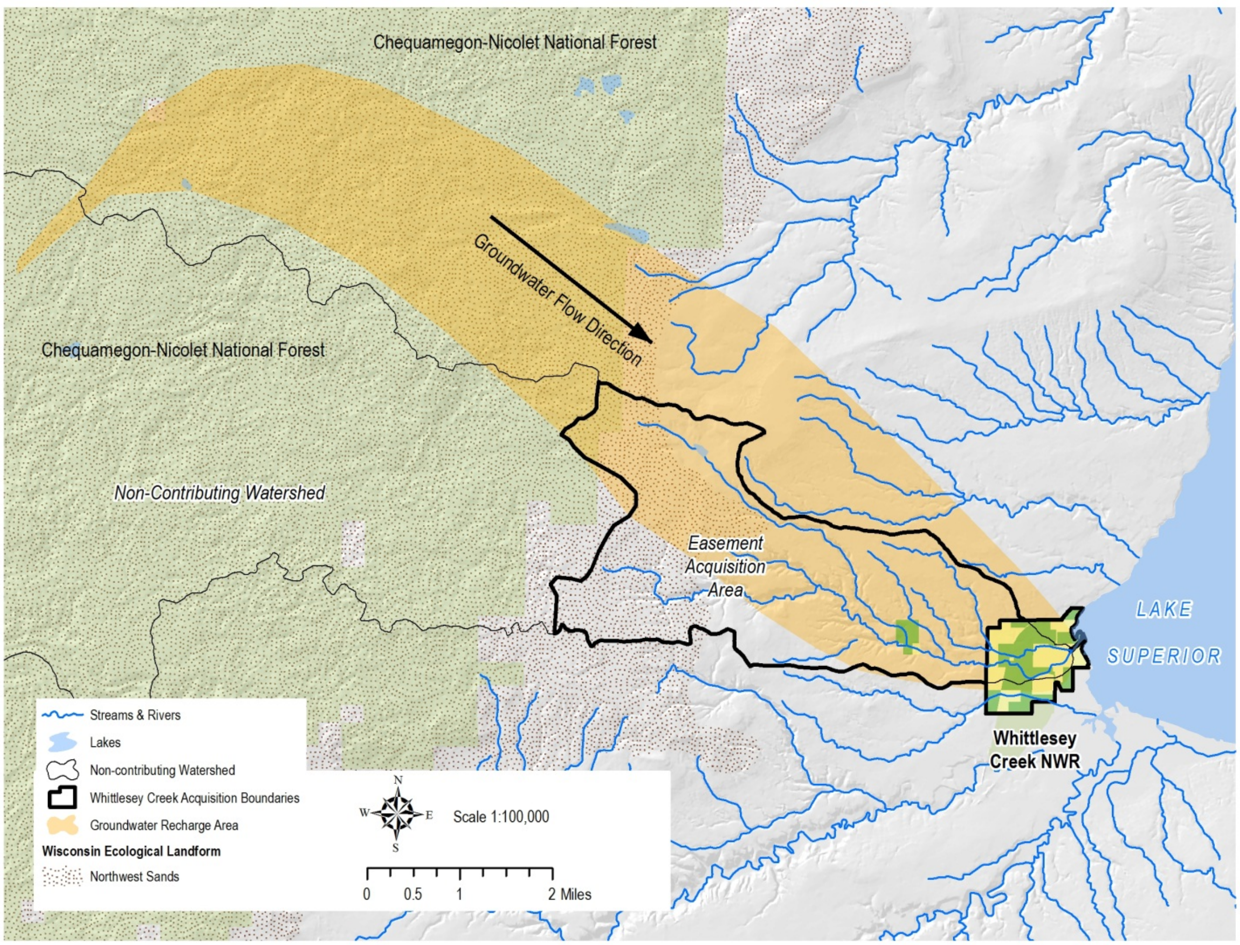
The deep flow system moves through the sandy Copper Falls Formation and into the Bayfield Group, discharging to Lake Superior and to deeply incised streams such as Whittlesey Creek. The main discharge area along Whittlesey Creek is near the North Fork confluence. This groundwater discharge provides the steady surface water flow at relatively constant temperature in the downstream reaches of Whittlesey Creek. Upstream of the North Fork confluence, Whittlesey Creek has little or no base flow; flow is from surface runoff and a small amount of perched groundwater from the shallow flow system (Lenz et al., 2003).

The shallow flow system is difficult to delineate but probably includes much of the area underlain by the Miller Creek Formation. It receives less recharge than the deep system because the Miller Creek Formation is less permeable than the Copper Falls Formation. Some groundwater from the shallow system discharges to Whittlesey Creek and some likely recharges the deep system. Alternating layers of sand and clay in the Miller Creek Formation can result in isolated, perched water separated from the deep system by 100 feet or more. These perched areas provide some discharge into the upper stretches of Whittlesey Creek but not enough to sustain year-round surface water flow (Lenz et al., 2003).

Lenz et al. (2003) delineated the area that contributes groundwater to Whittlesey Creek including both the deep flow system and the non-perched part of the shallow system. The twodimensional surface of the groundwater-contributing area is about 14,000 acres. Part of it overlaps the surface-water-contributing area, but much of it lies to the northwest within the Chequamegon-Nicollet National Forest. About 90 percent of the base flow to Whittlesey Creek originated as recharge through the sandy Copper Falls formation, the permeable deposits in the center of the Bayfield Peninsula. Only about 10 percent of base flow was from recharge through the clayey Miller Creek Formation. Median travel time of particles modeled from the stream back to the water table was about 94 years (Figure 3-5).

The most likely land cover change for the Whittlesey Creek groundwater-contributing area is logging of forests in the sandy zone. Logging can increase recharge by reducing interception and evapotranspiration. According to simulations, if logging in the ground-water-contributing area resulted in a 25 percent increase in recharge, the base flow of Whittlesey Creek would increase by about four percent (Lenz et al., 2003).

Figure 3-5: Groundwater



Little Whittlesey Creek

Little Whittlesey Creek is a short drainage with low base flow within the Whittlesey Creek watershed. Like Whittlesey Creek, some of the Refuge portion of Little Whittlesey was channelized in the 1940s. Little Whittlesey flows into the coastal wetland near the mouth of

Whittlesey Creek, but original land survey maps suggest that it historically emptied into Whittlesey Creek in Reach 2. When the Refuge was established, this stream had been degraded by intensive grazing and by limited development along its banks (FWS, 1998).

While area residents describe Little Whittlesey as a once productive brook trout stream, minimal population assessment data exist with few young-of-the-year coho and brook trout captured. Recent observations have noted the presence of at least a few spawning class coho salmon, although Little Whittlesey Creek is not listed as a designated trout stream (WDNR, 2002), indicating its low habitat value for trout compared to Whittlesey Creek. No habitat assessments have been conducted.

Terwilliger Creek

Terwilliger Creek lies south of Whittlesey Creek. After passing through the Refuge, Terwilliger flows under Highway 2 and empties into Fish Creek Sloughs. The watershed is about 1,400 acres. Original 19^{th} century land survey maps suggest that Terwilliger Creek historically was a tributary of Whittlesey Creek. Like the other two Refuge streams, the lower segment of Terwilliger was straightened in the 1940s. When the Refuge was established, this stretch was described as the most degraded portion of the creek (FWS, 1998).

No fishery or habitat assessments have been conducted. Terwilliger is closer to being a coolwater stream than a coldwater stream, although a few young-of-year salmon and small localized populations of brook trout sometimes are found near springs. Creek chubs, small northern pike, and a few other species are present. Terwilliger is not known to provide significant spawning habitat for salmonids and is not listed as a designated trout stream by the WDNR (2002).

Climate

The climate of northern Wisconsin along Lake Superior is moderated by the lake, creating longer spring and fall seasons, cooler summers, and increased precipitation when compared to inland areas. The average annual temperature over the last 30 years is about 40 °F, averaging 10 °F in January and 67 °F in July. The area averages 40 days with temperatures below 0 °F and six days above 90 °F.

Average annual precipitation is about 30 inches with the greatest amount falling from June to September. Average annual snowfall is 58 inches, which typically falls from November through March. The average growing season is from May 18 to October 1 (135 days).

Climate Change

Information in this section comes primarily from the publication *Wisconsin's Changing Climate: Impacts and Adaptation* (WICCI, 2011). The Wisconsin Initiative on Climate Change Impacts (WICCI) began as a collaborative project between the University of Wisconsin and the WDNR but has since grown to include representatives from other state and federal agencies, tribal organizations, businesses, and non-profit groups. WICCI scientists have analyzed the historical climate of Wisconsin and are developing and refining models of future climate change. They also are assessing the potential impacts of climate change on natural and human systems across the state including wildlife habitat, water resources, forestry, agriculture, tourism, infrastructure, and human health. The focus is on developing practical information for public and private decision-makers at all levels that will aid in determining appropriate climate change adaptation strategies.

Climate change will interact with and exacerbate other stressors—including habitat loss and fragmentation, invasive species, and pollution—amplifying the challenges they pose to natural habitats and biodiversity. Through proper stewardship, protected habitats can be maintained to promote the highest levels of natural resilience to change

Temperature and Precipitation

On an annual average, Wisconsin warmed about 1.1 °F between 1950 and 2006; the northwestern part of the state has warmed a bit more than the rest. Winter temperatures have risen most significantly. Statewide, winter temperatures have increased 2.5 °F, while increases of 3.5 to 4.5 °F have occurred in northwestern Wisconsin. Summer and fall temperatures have changed the least. Nighttime temperatures have increased more than daytime temperatures.

These temperature changes are likely to intensify into the future. The average mean projected warming rate is about four times greater than what has been observed since 1950. The warming is projected to be largest in winter, with projected increases of 5 to 11 °F by the mid-21st century across Wisconsin, and the greatest warming in northwestern Wisconsin. By mid-century, the growing season in Wisconsin is expected to lengthen by one month.

Wisconsin as a whole has become wetter since 1950, with a 10 percent average increase in annual precipitation. Most of the increase has been concentrated in southern and western Wisconsin. Northern Wisconsin has become drier, annually averaging one to two inches less precipitation over that period. It is unclear whether these trends are due to climate change or represent natural variation in rainfall over Wisconsin.

Projections of future precipitation are less certain than projections of temperature, with considerable disagreement among climate models. However, the models do indicate a 75 percent probability that annual average precipitation in Wisconsin will increase. The models are in considerable agreement that precipitation will increase during winter and show a fair level of confidence that spring and fall precipitation will increase. However, climate models do not agree on how precipitation patterns are likely to change in the summer. By mid-century, Wisconsin will likely have two or three additional intense rainfall events (at least two inches in a 24-hour period) per decade, about a 25 percent increase in frequency.

Hydrology

Temperature and precipitation changes will affect Wisconsin's water cycles, with impacts on lakes, streams, groundwater, and wetlands. Spatially, the state will not be affected uniformly. Differences in the characteristics of a place—such as variations in land use, soil type, groundwater characteristics, and runoff and seepage—can confound the influence of climate change, leading to a wide range in system responses. Some of the expected hydrologic responses to climate change in Wisconsin include:

- Increased average surface water and groundwater temperatures;
- Shorter periods of ice cover on lakes and streams;
- Increased evapotranspiration rates during the longer growing season;

- Increased number of freeze-thaw events;
- More groundwater recharge due to increases in winter and spring precipitation;
- Changes in recharge and discharge patterns as more precipitation falls as rain or snow; and
- Increased number of high water events causing flooding.

Coastal Wetlands

Although many uncertainties remain, the current scientific consensus is that the average water level of Lake Superior will be slightly lower by the end of the century, although water levels will fluctuate widely around the average. The combination of warmer temperatures and reduced ice cover will contribute to greater evaporation, which eventually is expected to exceed the increases in precipitation. Continued increases in temperature, changing lake levels, and increased upland runoff and flooding are expected to affect the food web, plant community composition, and overall quality of coastal wetland habitats. Plant diversity will likely decrease and boreal wetland species could be lost altogether in northern Wisconsin. Increasing temperatures could give weedy plant species a competitive advantage.

Coldwater Streams

Potential effects of climate change that can affect coldwater streams include rising water temperatures, altered groundwater recharge and stream base flow, and an increase in large runoff events from heavy storms. Models show that all coldwater habitats and fish species in Wisconsin will be reduced because increases in air temperature produce increases in water temperatures in nearly all coldwater streams.

Stream vulnerability will vary geographically across Wisconsin and within regions because differences in the characteristics of streams and their watersheds lead to variance in the capacity to buffer changes in water temperature. In undisturbed watersheds with sufficient groundwater input, for example, streams may be well buffered to climate change impacts, while those in urbanized watersheds or agricultural areas may be more vulnerable.

Federal, state, and academic partners are using local data on climate, land use, hydrology, and stream characteristics to study potential impacts of climate change on coldwater streams that are part of the Great Lakes system. Current data indicate that streams on the Bayfield Peninsula are more likely than many other parts of Wisconsin to retain high quality coldwater habitat, and Whittlesey Creek conditions are expected to remain highly suitable for brook trout (Lyons et al., 2010; Mitro et al., 2010).

Forests

A warming climate will reduce suitable habitat and increase stress in boreal forest species currently at the southern edge of their natural range in Wisconsin, such as aspen, white birch, white spruce, black spruce, balsam fir, jack pine, and red pine. Lowland forests of black spruce and tamarack (*Larix laricina*) in northern Wisconsin are sensitive to changes in water tables and snow cover; less snow could cause freezing of fine root systems and changes in the water table could flood or dry the shallow wetland soils needed to establish seedlings. Hardwood trees, such as hickory, black oak, and black walnut are predicted to expand their range within the state as temperatures rise. Species under increased stress will be more susceptible to damage from insects and diseases.

Wildlife

The earlier arrival of spring is altering the timing of seasonal activities such as reproduction and migration for many plants and animals. For example, Canada geese now arrive in Wisconsin a month earlier than in the 1930s, cardinals begin singing 22 days earlier, and robins arrive nine days earlier. Different species are responding to climate change at different rates, which can lead to negative impacts such as lack of food if birds reach their summer breeding grounds before their insect prey have hatched. Some species will be forced out of Wisconsin as habitat conditions change. Others may be unable to make the move to new areas and will face population declines.

Cold temperatures and deep snow cause physical stress in white-tailed deer that can lead to high death rates. Projected winter warming will reduce this source of mortality and could lead to larger deer herds with increased impacts on croplands, forest, and native vegetation. Deer populations also may be exposed to more diseases due to changing temperature and precipitation patterns. The American marten, a state-endangered species now found only in very small numbers in the northern counties, relies on snow cover for insulation during the winter, but the predicted 40 percent loss of snow cover during the next half century could permanently eliminate the marten in Wisconsin. Rodents and other small mammals, a major food source for martens and fishers, also rely on snow cover to survive the winter and could face permanent population declines.

The wood frog, found across most of Wisconsin, can freeze during the winter, but cannot endure temperatures lower than 21 °F. Snow cover is important to the wood frog for thermal insulation. The species also needs temporary ponds close to woodlands for successful breeding, but wood frogs rarely travel more than a mile so cannot move away from widespread drought conditions. Reduced snow cover and more variable precipitation patterns are expected to have substantial impacts on this species over the next half century. This fate will be shared by many amphibian species and other poor dispersers that, in turn, are food sources for birds, reptiles, and small mammals.

Fish

Coldwater species are at risk as air and water temperatures increase. Brook trout in particular are especially sensitive to environmental changes and have a narrow temperature range in which they can successfully live, feed, and reproduce. Wisconsin is at the edge of the range of native brook trout. If their distribution shifts north due to the habitat effects of climate change, Wisconsin will lose many of its brook trout populations in the coming decades.

Climate change models indicate that higher temperatures will threaten the viability of brook trout populations throughout Wisconsin. Initial models predicted that brook trout would be completely lost from Wisconsin streams under the worst-case scenario, and even the best-case scenario predicted 44 percent less brook trout habitat by mid-century (Mitro et al., 2010). Second generation modeling now underway incorporates improved data on precipitation and groundwater influences. The initial results still do not look favorable for brook trout overall, although not as bad as first generation models predicted (John Lyons, personal communication). Whittlesey Creek is still projected to remain highly suitable for brook trout, even as coldwater habitat is lost in many other locations, so may become more important as one of the last remaining sites in the area (Lyons et al., 2010; Mitro et al., 2010).

Warmwater fish species such as smallmouth bass, largemouth bass, black crappie, and channel catfish will benefit from rising Wisconsin stream temperatures, but the length of stream habitat that warmwater fish are projected to gain is much less than the length of habitat coldwater fish stand to lose.

3.3 Biological Environment

Resources of Concern

The management direction of each national wildlife refuge is driven first by the purpose(s) and statutory mandates of the refuge, coupled with species and habitat priorities that are also known as resources of concern (FWS, 2010). Priority resources of concern guiding fish, wildlife, and habitat management programs on Whittlesey Creek NWR were established as part of the Refuge's habitat management plan (HMP) (FWS, 2006c). Four habitat types were identified, along with associated species of concern that have limiting attributes associated with that habitat type (Table 3-1).

Table 3-1: Whittlesey Creek NWR Priority Resources of Concern

	Priority habitats			
Priority species	Coldwater stream	Lowland forest/shrub	Riparian forest	Coastal Wetland
Coaster brook trout	x			
Wood turtle	x		x	
Water shrew	x			
Northern waterthrush		x		
Northern black currant		x		
Marsh horsetail		x		
Veery		x	x	
Black duck				x
Common mudpuppy				x
Sora rail				x

Coldwater Streams

Coldwater streams that pass through the Refuge (Whittlesey, Little Whittlesey, and Terwilliger Creeks) are described under the "Hydrology" heading in Section 3.2 of this Comprehensive Conservation Plan (CCP). Associated species of concern are coaster brook trout *(Salvelinus fontinalis*), wood turtle (*Clemmys insculpta*), and water shrew (*Sorex palustris*).

Coaster brook trout depend on accessible coldwater streams for resting, feeding, spawning, and nursery, and are very sensitive to in-stream habitat degradation. The state-endangered wood turtle prefers lowland habitats associated with medium to fast current streams with sand or gravel substrates; they often nest in sandy stream banks. The water shrew requires coldwater streams with high water quality and abundant cover such as rocks, logs, or overhanging stream banks.

Lowland Forest and Shrub

Lowland forest and shrub are found mainly in the floodplain and coastal wetland areas of the Refuge, as well as other public lands at the head of Chequamegon Bay including the NGLVC (USFS), Fish Creek Sloughs (WDNR), and Prentice Park (City of Ashland). Dominant plant species include willow (*Salix spp.*), speckled alder (*Alnus rugosa*), white cedar (*Thuja occidentalis*), trembling aspen (*Populus tremulouides*), black ash (*Fraxinus nigra*), and red maple (*Acer rubrum*). Important functions of this habitat type are floodwater storage, primary production, and wildlife habitat. Species of concern are northern waterthrush (*Seiurus noveboracensis*), veery (*Catharus fuscescens*), northern black currant (*Ribes hudsonianum*), and marsh horsetail (*Equisetum palustre*).

The northern waterthrush favors wooded stream banks during breeding season and prefers nest sites in exposed root masses of fallen trees. The veery uses large patches of swampy forest, especially with a shrubby understory. Northern black currant is found mostly in shaded to partly shaded areas of cold conifer swamps; it is found on the Refuge at the edge of a conifer and black ash swamp. Marsh horsetail is found along Terwilliger Creek; it usually is found in moist settings in variable habitats including fens, alder thickets, sedge meadows, and bog and swamp margins.

Riparian Forest

Riparian forest was separated from lowland forest because of stream interface and the functions riparian vegetation provide for hydrology and habitat. Mature trees will fall into the stream and create habitat for aquatic species. Roots help to keep banks stable. Overhanging vegetation helps keep the water cool and provides cover for fauna. Non-native crack willow (*Salix fragilis*) was planted in in the riparian zone in the 1940s and 1950s. Large American elm (*Ulmus americana*) dominated the Refuge riparian zone until the 1970s when Dutch elm disease nearly eliminated them. Today, few mature trees remain along Refuge creeks. Species of concern for this habitat type are veery and wood turtle.

In addition to large patches of swampy forest, the veery also likes second growth willow or alder shrubbery near water. Hatchling and juvenile wood turtles prefer alder thickets associated with shorelines, which are considered critical habitat for this segment of the population.

Coastal Wetland

Coastal wetland is found where the waters of Lake Superior influence vegetation along the shore. Most coastal wetland on the Refuge would be considered a complex of emergent marsh edged with lowland shrub. Water levels and plant communities are dynamic. Changes in Lake Superior water levels have influenced this habitat type for thousands of years. Isostatic rebound from the weight of past glaciers raises the water level by about one foot per century, flooding historic shoreline habitat and stream mouths. Shorter-term influences include natural surface water oscillations (called seiches) and variable rainfall and snowmelt. Wave and wind action rework sediments carried downstream by Whittlesey and Little Whittlesey Creeks. These wetlands assimilate nutrients, store floodwaters, and provide nursery areas for fish, frogs, and waterbirds. Species of concern are black duck (*Anas rubripes*), common mudpuppy (*Necturus maculosus*), and sora rail (*Porzana carolina*).

The black duck uses diverse habitat, favoring wooded swamps and marshes; they overwinter on the Refuge at the mouth of Whittlesey Creek and in open spring ponds. Mudpuppies typically congregate in river mouths and harbors of Lake Superior, but their status on the Refuge is unknown; they are thought to be sensitive to pesticides, including the lampricides that are used on many other Lake Superior streams. Fish Creek, adjacent to the Refuge, is treated with lampricide about every five years. Whittlesey Creek was last sampled for larval lamprey in 2005, and none was present. Little Whittlesey and Terwilliger Creeks haven't been sampled; all three creeks are scheduled for 2015. Soras are found primarily in shallow freshwater emergent wetlands, sometimes foraging on nearby mudflats; they have been heard and seen in cattail cover on restored Refuge wetlands during breeding season.

Land Cover

Historic

The original 19th century land surveys indicate that historic vegetation of the Refuge and vicinity included three forest types. Conifer swamp extended from the mouth of Fish Creek onto property now owned by the NGLVC and up to Whittlesey Creek. Tree species included northern white cedar (*Thuja occidentalis*), black spruce, tamarack, balsam fir (*Abies balsamea*), and black ash (*Fraxinus nigra*). The white-red pine forest was located on the northern edge of the current Refuge boundary, at a higher elevation than the conifer swamp. Boreal forest was south of the conifer swamp and would have included aspen (*Populus spp.*), paper birch (*Betula papyrifera*), white spruce (*Picea glauca*), balsam fir, red pine (*Pinus resinosa*), and white pine (*Pinus strobus*) (Finley, 1976; FWS, 2006c).

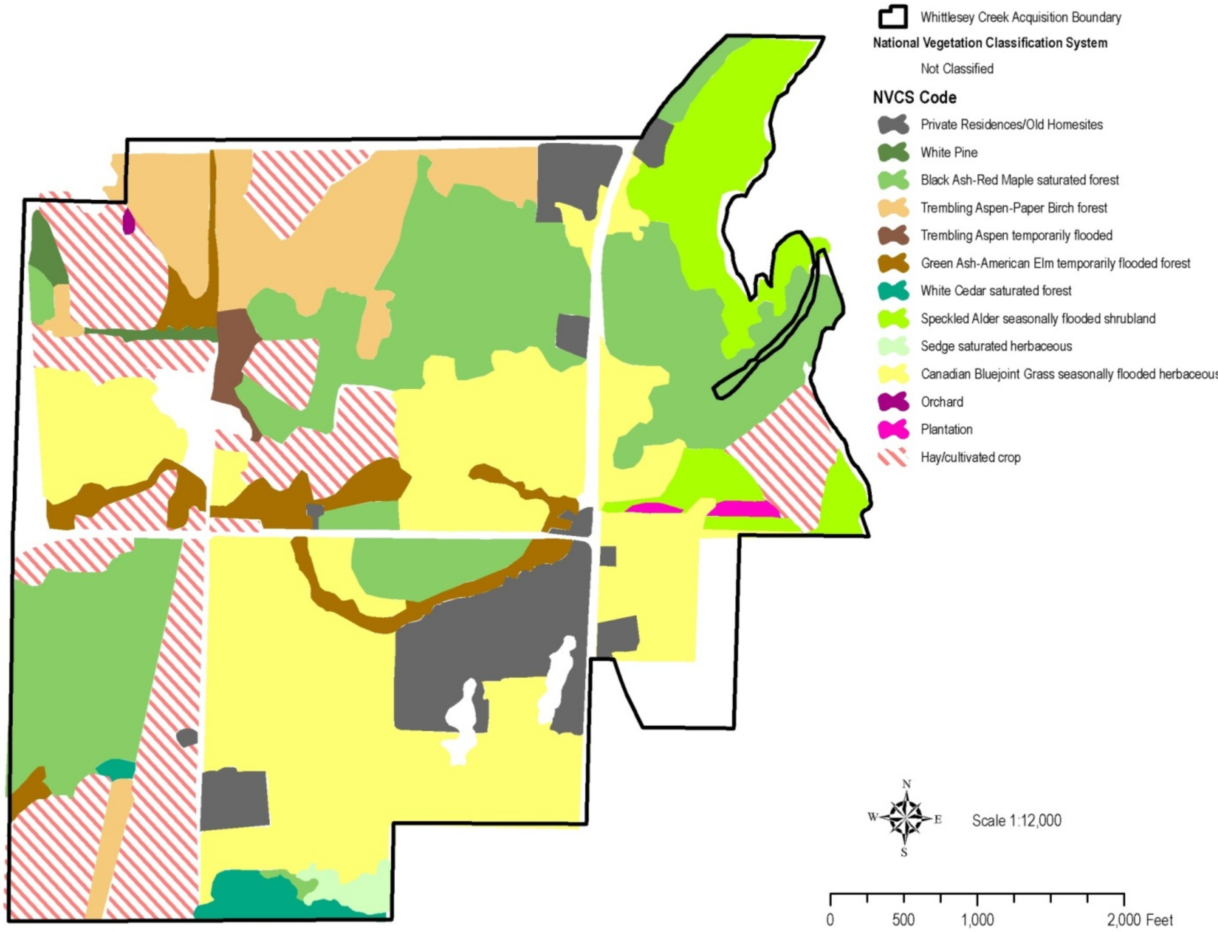
By the early 20th century, most timber had been harvested and much of the land within the current Refuge boundary was farmed or grazed. These lands probably were often too wet from floods or high groundwater to produce consistent crops. When Whittlesey Creek NWR was established in 1999, only about 90 acres were still hayed or pastured, and no annually tilled cropland remained. Most of the former farmland had regrown with water-tolerant trees and shrubs such as willows, white cedar, black ash, and speckled alder (*Alnus rugosa*). Reed canarygrass (*Phalaris arundinacea*) dominated many old hayfields.

Current

2006 Vegetation

A vegetation map of the Refuge was developed as part of the HMP (FWS, 2006c). Vegetation cover types were delineated based on aerial photographs and field surveys and followed the National Vegetation Classification System (NVCS) (Federal Geographic Data Committee, 1997) (Figure 3-6).

Figure 3-6: Refuge Vegetation Map from 2006 Habitat Management Plan



2013 Vegetation

The Refuge has not been mapped according to the NVCS since originally done for the 2006 HMP. A more general watershed-wide land cover map was developed for this document (Figures 3-7 and 3-8). As land has been acquired and haying has been greatly reduced on the Refuge, natural succession is transitioning many areas to shrubs and trees. Native conifers have been planted on approximately 62 acres, and 180 suitable acres within the acquisition boundary remain unplanted. Tentative plans include planting 60 acres during 2015.

Figure 3-7: Refuge Land Cover (2013)

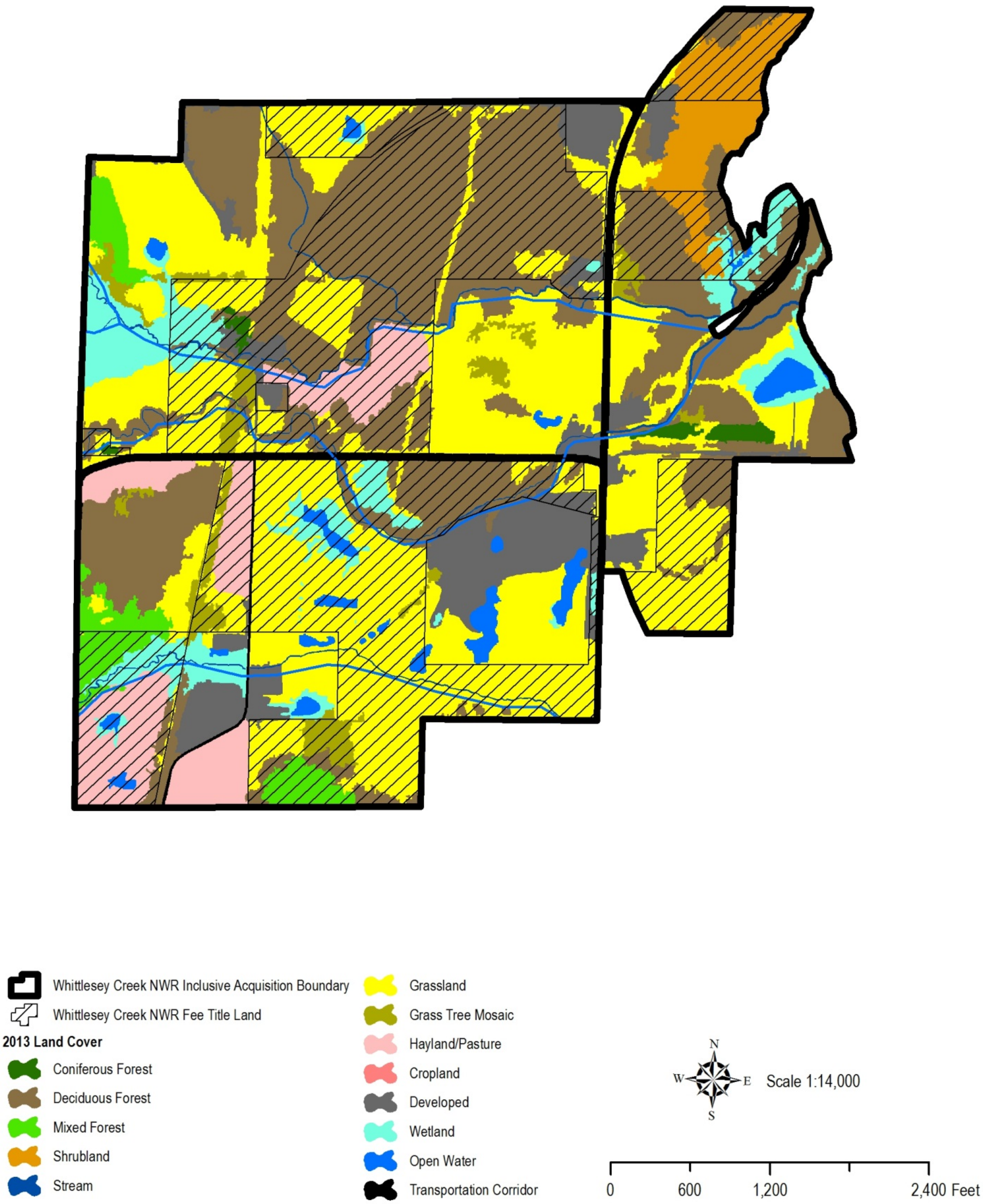
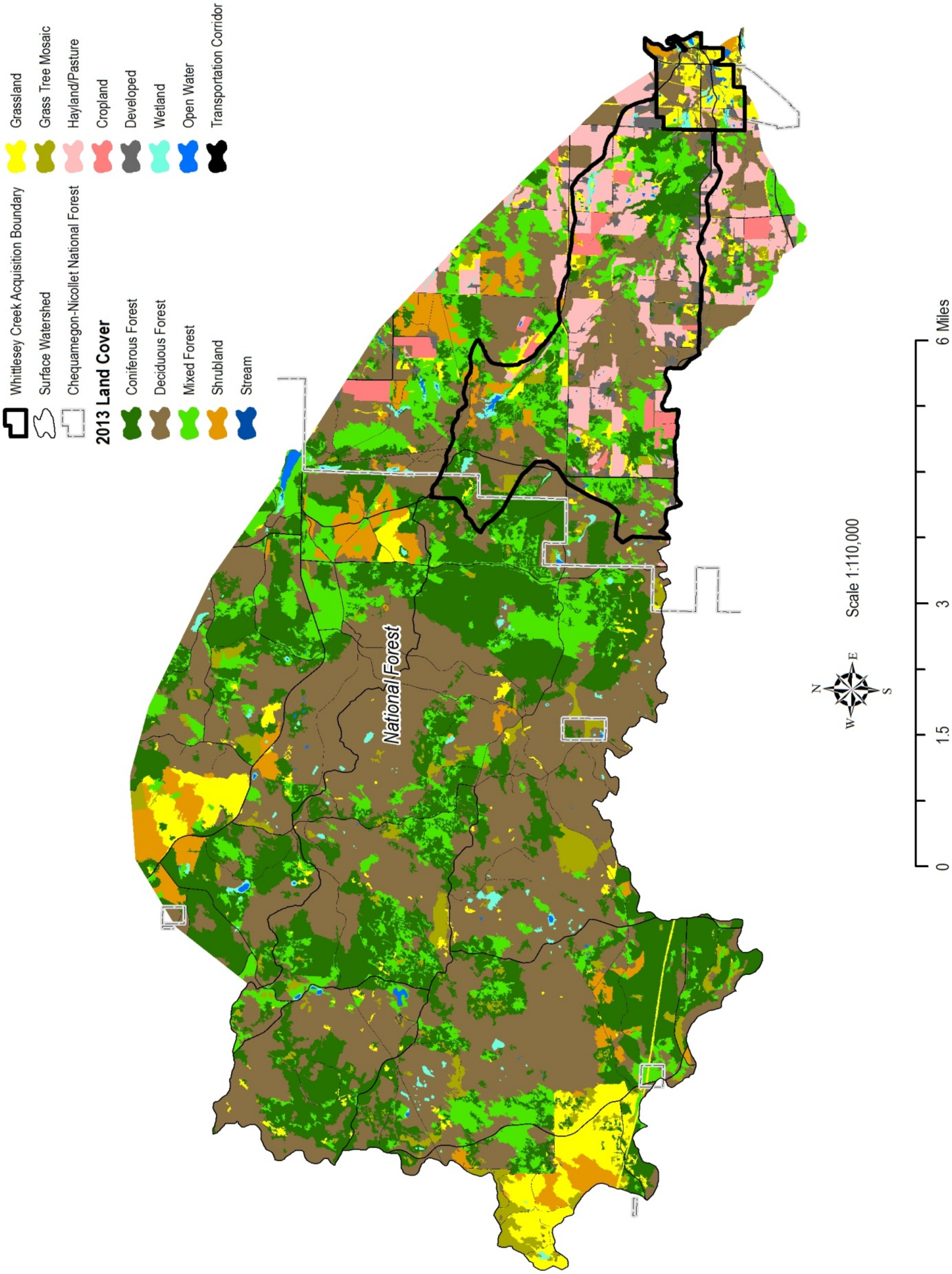


Figure 3-8: Refuge and Watershed Land Cover (2013)



Currently, watershed land cover is dominated by forests in public (USFS) and private ownership. Forest Service lands are part of the Washburn District of the Chequamegon-Nicolet National Forest. These holdings include barrens habitat. Private woodlands are owned by individuals and timber companies. Farm numbers and crop acreage continue to decline. Few dairy farms remain and animal agriculture is dominated by beef and horses. Hayland and pasture typically are not intensively managed. Annual crops include corn, soybeans, oats and wheat with acreage fluctuating based on commodity prices, crop rotations, and subsidies. Development includes farmsteads and low-density rural residential properties.

Fish and Wildlife Communities

Fish

The historic native fish community of Whittlesey Creek, like most coldwater, spring fed tributaries to Lake Superior during pre-European settlement times, consisted primarily of brook trout (*Salvelinus fontinalis*) and slimy sculpin (*Cottus cognatus*). As waters warmed slightly as they flowed downstream, and becoming influenced by the seiche of Lake Superior, native ninespine stickleback (*Pungitius pungitius*), brook stickleback (*Culaea inconstans*), common shiner (*Luxilis cornutus*), spottail shiner (*Notropis hudsonius*), blackchin shiner, (*Notropis heterodon*), blacknose dace (*Rhinichthys atratulus*), Johnny darter (*Etheostoma nigrum*), creek chub (*Semotilus atromaculatus*), and white sucker (*Catostomus commersonii*) also occurred.

Today, because of intentional or inadvertent introductions, and alterations to the habitat within the watershed, the fish community of Whittlesey Creek is dominated by non-native species. Non-native fish species found in Whittlesey Creek today include brown trout (*Salmo trutta*), tiger trout (brown trout/brook trout hybrid), rainbow trout/steelhead (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*), pink salmon (*Oncorhynchus gorbuscha*), splake (lake trout/brook trout hybrid), and rainbow smelt (*Osmerus mordax*). Although native to the area, fathead minnow (*Pimephales promelas*), pumpkinseed sunfish (*Lepomis gibbosus*), and central mudminnow (*Umbra limi*) were not historically found in Whittlesey Creek but have recently been collected, likely entering Whittlesey Creek via flood waters from ponds being breached in the uplands within the watershed. An experiment to reestablish a self-sustaining population of native coaster brook trout in Whittlesey Creek has been underway since 2003 (FWS and WNDR, 2003).

Coaster Brook Trout

Background
The coaster brook trout (coaster) is a migratory form of brook trout found only in the Great Lakes basin. Unlike brook trout that live year round in streams, coasters spend part of their life in the Great Lakes, returning to tributary streams in late summer or fall to spawn. A few coaster populations spend their entire life in the lake, spawning in rocky areas near shore. The highly productive Great Lakes allow coasters to reach very large sizes. Coasters are not a genetically distinct brook trout, but rather some stream-resident populations appear to have the ability to produce a migratory life history when conditions are suitable. In 2009, the Service found that coaster brook trout in the Great Lakes are not eligible for listing under the Endangered Species Act (74 FR 23376).

Restoration of self-sustaining brook trout populations is a priority for many conservation agencies and organizations working in the Lake Superior basin, including the Great Lakes

Fishery Commission (GLFC), the Lake Superior Landscape Restoration Partnership, and the WDNR. Coaster brook trout is a resource conservation priority (FWS, 2002) and a species of concern for the Midwest Region of FWS (see the FWS Species of Concern web page at http://www.fws.gov/midwest/es/soc/index.html) and for Whittlesey Creek NWR (FWS, 2006c). Brook trout was selected as a surrogate species in the Upper Midwest Great Lakes geography (FWS, 2014). The interagency Whittlesey Creek brook trout restoration experiment (FWS and WDNR, 2003) is intended to serve as a model for other streams in the future.

History and Decline

Brook trout were widespread in the Lake Superior basin prior to European settlement. Most Lake Superior tributaries with cool temperatures probably supported resident brook trout year round and spawning coaster brook trout in the fall, although historic population information is limited because numbers were greatly reduced or even eliminated in some areas before any rigorous data could be collected. Newspaper articles, letters, and other reports from the latter half of the 19th century describe abundant coaster brook trout populations and document their occurrence in at least 45 streams in Ontario, 25 in Michigan, 12 in Wisconsin, and nine in Minnesota. Small numbers of coasters also occurred historically in Lake Huron and its tributaries (Enterline, 2000).

"... over to Whittlesey's Creek where that gentleman succeeded in a few hours fishing, in capturing 75 trout, while Charley raised the number to an even hundred ..."

April 20, 1878 – The Ashland Press

During the late 19th century, sportsmen from all over North America were coming to Lake Superior to fish for coasters, which were highly valued because of their abundance, ease of harvest, bright coloration, and large size. As early as the 1880s, however, severe declines in the fishery were noted in local newspapers and were associated with a combination of excessive harvest and habitat changes caused by logging (Table 3-2). Clear-cutting and subsequent fires left soil prone to excessive erosion. Dams were often constructed across confined stream valleys to form impoundments. These were filled with logs, dams were breached, and logs were driven downstream to sawmills. Angling success generally declined in a progression from easily reached streams to more remote streams and from lower stream reaches to upper stream reaches. Commercial harvest along the coastline accelerated the decline (WDNR and FWS, 2005).

Table 3-2: Timeline of Coaster Brook Trout Decline and Restoration

			1830s	1837	Ojibwe cede lands in northwest Wisconsin to United States
			1840s		
Sportsman's Paradise			**1850s**	1855	Sault Ste. Marie canal connects Lake Superior to Lake Huron
	Logging Era		**1860s**		
			1870s	1877	Wisconsin Central Railroad reaches shore of Lake Superior
Mining Era			**1880s**		Coaster brook trout decline becomes apparent
			1890s		Introduction of non-native trout begins
		Trout Stocking Era	**1900s**		
	Farming Era		**1910s**	1916	First brook trout stocking in Whittlesey Creek
			1920s		
			1930s		Smelt and sea lamprey invasions
			1940s		
			1950s		Only a few coaster brook trout populations still exist Introduction of non-native salmon begins
			1960s	1958-1964	Erosion control efforts in Whittlesey Creek watershed by Red Clay Interagency Committee
			1970s		
			1980s		
		Collaborative Restoration Era	**1990s**	1990	GLFC establishes fishery objectives for Lake Superior
				1999	FWS establishes Whittlesey Creek NWR
					GLFC completes Lake Superior brook trout plan
			2000s	2003	Whittlesey Creek brook trout experiment and evaluation begins
			2010s		Climate change models indicate Whittlesey Creek is resilient and will remain suitable for brook trout through mid-century

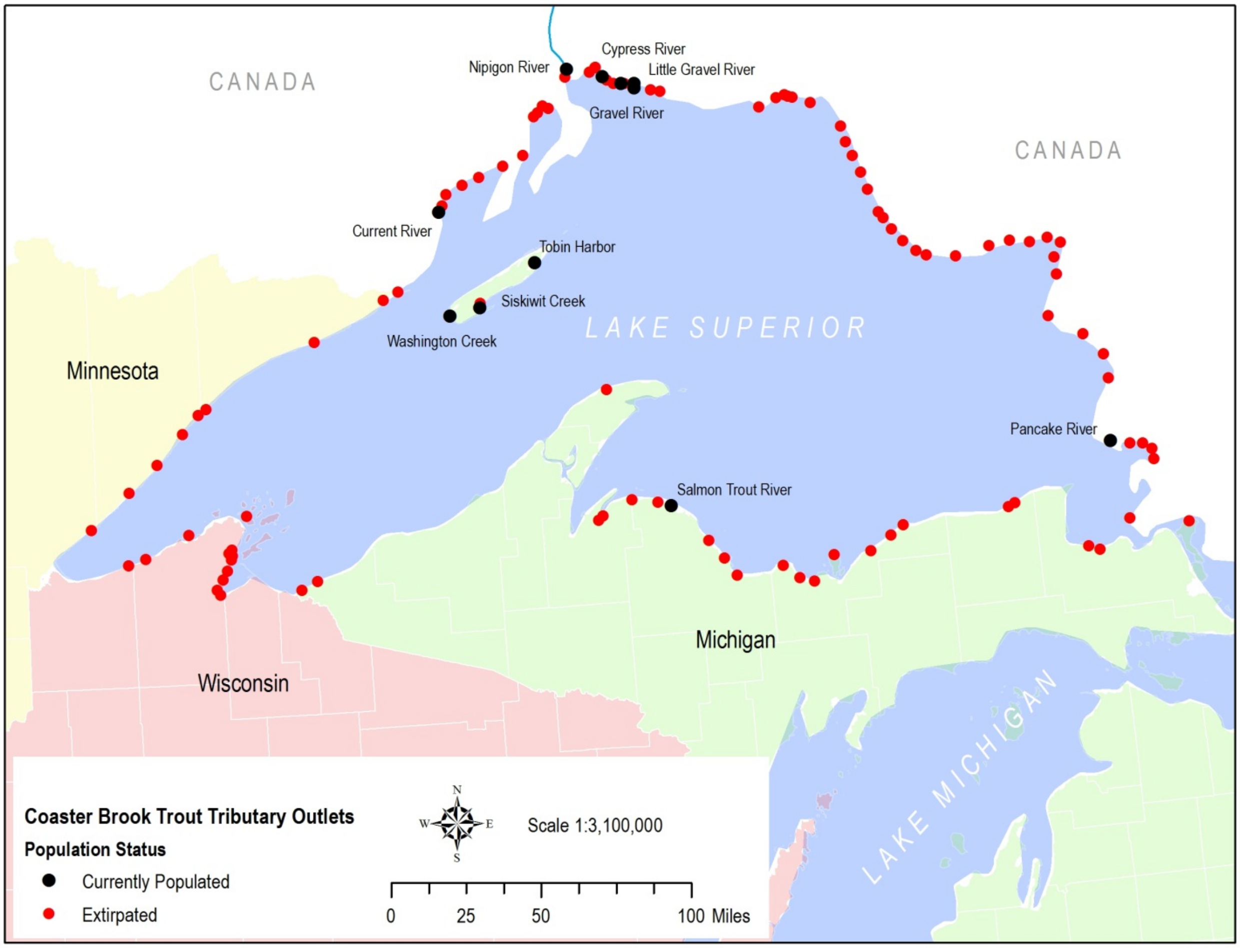
"Old-timers tell stories about the wonderful trout fishing they used to have but how now . . . good trout fishing is a thing of the past." — 1957 Red Clay Interagency Committee

The exploitation of coaster stocks and demands on their habitat continued in the 20th century. The opening of the Lake Superior basin by road, rail, and water ended the area's isolation. Brook trout habitat was degraded by logging, mining, agriculture, and stream modifications as settlement and development increased. Intensive harvest via commercial and sport fishing continued. Invasion of sea lamprey and smelt in in the 1930s, and introduction of non-native trout (late 1890s) and salmon (1950s–1970s) also may have contributed to the range-wide decline of native coasters. By 1950, viable coaster populations were reduced to a few remnants in Ontario, Michigan, and Minnesota. While the coaster form of brook trout suffered the most conspicuous losses, stream-resident brook trout populations were also greatly reduced (Newman and Dubois, 1996). Fishing success in Whittlesey Creek was described as "almost non-existent" (Red Clay Interagency Committee, 1957).

Restoration

Extensive efforts to bolster declining coaster brook trout populations began in the late 19th century (Table 3-2), largely through stocking of various strains of brook trout in the Lake Superior basin. In Wisconsin, the first officially recorded stocking occurred in 1890 when a resort owner put brook trout in the Sioux River. Over the next 100 years, more than 23 million brook trout were stocked in Wisconsin's Lake Superior streams and near-shore waters. The first documented fish stocking in Whittlesey Creek occurred in 1916. By 1995, about 178,000 brook trout, 16,000 rainbow trout, and 114,000 brown trout had been stocked in Whittlesey Creek (WDNR and FWS, 2005) (Figure 3-9).

Figure 3-9: Historic and Current Range of Self-Sustaining Coaster Brook Trout Populations in the Lake Superior Basin



In 1956, the Red Clay Interagency Committee was formed in northwest Wisconsin to reduce erosion of clay soils in the Lake Superior basin that was causing water quality problems and reducing trout populations. Attention was focused on the Whittlesey Creek watershed as a good site for an intensive pilot study, although other watersheds also were included. Experimental erosion control methods developed and tested over the next several years included road and stream bank seeding, tree planting, livestock fence installation, and stream modifications to divert water flow (Red Clay Interagency Committee; 1957, 1960, 1964).

None of the efforts to reestablish naturally reproducing populations of coasters was successful, probably due to a combination of factors such as weak harvest regulations, ineffective stocking practices, ongoing habitat loss, and competition from non-native species. Until recently, little was known about the species, which further complicated restoration efforts. By the late 20th century, the only documented coaster brook trout populations of significant size were found in the Nipigon River region of Ontario, in some streams and near-shore areas at Isle Royale National Park, and in Michigan's Salmon Trout River.

Organizations and tribes across the basin began to recognize the need for collaborative programs that addressed all of the causes of coaster brook trout decline. In 1990, members of the GLFC developed fish community objectives for Lake Superior that seek, in part, to “re-establish depleted stocks of native species such as the lake sturgeon, brook trout, and walleye.” The GLFC began documenting the status of coaster brook trout in 1993 (Newman and Dubois, 1996) and completed “A Brook Trout Plan for Lake Superior” in 1999 (Newman et al., 2003). The plan provided guidelines for rehabilitation efforts, leaving individual states and agencies responsible for developing and implementing their own action plans. The goal is to maintain widely distributed, self-sustaining populations of brook trout throughout their original habitats. Priority actions include restoring tributary habitat, regulating harvest, stocking genetically appropriate strains, building public support, researching brook trout life history, and monitoring progress. Twenty-six organizations and agencies from across the Lake Superior basin are currently involved in coaster rehabilitation efforts guided by recommendations set forth in the plan. The Ashland Fish and Wildlife Conservation Office is the Service lead for coaster brook trout research and conservation.

Both Wisconsin and Minnesota have created state-specific rehabilitation plans for Lake Superior brook trout. Whittlesey Creek is one of five priority streams named in the Wisconsin plan, which was jointly developed by the WDNR and the Service (WDNR and FWS, 2005). The Refuge was established in 1999 and the Whittlesey Creek brook trout experiment began in 2003.

Migratory Birds

Land use changes and bird range expansion and contraction are evident on the Whittlesey Creek NWR as well as throughout the Whittlesey Creek watershed and Chequamegon Bay region. Oral history interviews conducted during Refuge HMP development and informal conversations with long-term residents provide valuable insights. For example, sharp-tailed grouse populations were high when forests were young, and small dairy farms were common. Snow goose migrations provided exceptional hunting opportunities, and Canada goose numbers were minimal. As is the case throughout their historic range, bald eagle populations crashed due to toxin contamination. The species is now common during all seasons and regularly breeds in the area. Sandhill crane, northern cardinal, and wild turkey were rarely seen several decades ago. Now all have well-established breeding populations.

Whittlesey Creek NWR is part of the Lower Chequamegon Bay Important Bird Area. The 2006 Refuge HMP indicates that birders and biologists have identified 271 bird species in the vicinity, including waterfowl, neotropical migrants, raptors, grassland, and shore birds. These can be found in appendix B. Wetlands, woodlands in the watershed, and agricultural grasslands provide resting and breeding habitat for waterfowl and neotropical migratory birds. Piping plover and red knot have been a rare sighting in the spring at the mouth of Whittlesey Creek. Chequamegon Bay contains artificial nesting islands for common terns, one of two nesting locations on Lake Superior in Wisconsin and one of only five nesting sites in the state. The terns often feed on small fish in the shallows at the mouth of Whittlesey Creek. Large rafts of diving ducks, primarily lesser scaup, utilize Chequamegon Bay during migration, providing excellent fall open-water hunting. Limited numbers of overwintering American black ducks and mallards are found in the open water at the mouth of Whittlesey Creek, nearby Fish Creek, and in spring ponds.

Resident Species

Brady and Verch (2007) compiled a list of over 300 bird species that have been observed at least once in the Chequamegon Bay region since 1972. Nearly 170 are known to breed in the area. They note that this portion of Lake Superior’s south shore features diverse habitats including open water, mudflats, coastal wetlands, open fields, pine barrens, shrublands and varied forest types. All of these habitats are represented in the Whittlesey Creek watershed; they support a wide variety of dependent species during breeding, migration, and winter seasons. While relative annual abundance and occurrence may be inconsistent, 90 of the species have been recorded during all four seasons. Approximately 50 species are residents but several of these are represented by very limited numbers in scattered locations.

Threatened and Endangered Species

Wisconsin's gray wolf (*Canis lupus*) population is federally listed as endangered. The gray wolf is an uncommon visitor to Whittlesey Creek NWR.

The piping plover (*Charadrius melodus*) is federally listed as endangered in Wisconsin's Great Lakes watershed. It nests on bare shoreline adjacent to water. It is known to nest on Lake Superior shoreline in a few locations, including Long Island in Chequamegon Bay. There are no records of nesting pairs on or in the immediate vicinity of the Refuge. Piping plovers have been seen near the mouth of Whittlesey Creek during spring migration.

Canada lynx (*Lynx canadensis*) is federally listed as threatened in Wisconsin and is considered to be very rare with only a few recorded sightings in the past 25 years. Bayfield and Ashland counties are included in the list of counties with the highest likelihood of occurrence.

The rufa subspecies of the red knot (*Calidris canutus rufa*) is federally listed as endangered in Wisconsin. It is a rare spring migrant in the Chequamegon Bay region. It has been observed at the mouth of Whittlesey Creek, but there are no records of nesting pairs on or in the immediate vicinity of the Refuge.

Northern long-eared bat (*Myotis septentrionalis*) currently is proposed for listing as federally endangered. None of the Refuge parcels has known suitable winter habitat or suitable spring staging/fall swarming habitat. However, most have the potential to include suitable summer habitat. Monitoring via acoustic recording, initiated on the Refuge by the Service in April 2014, will help determine presence or absence of the northern long-eared bat.

3.4 Socioeconomic Environment

Demographics

Whittlesey Creek NWR is located in Bayfield County along the shore of Lake Superior in northwest Wisconsin. The population of Bayfield County was about 15,000 in the 2010 census (U.S. Census Bureau, 2013). The Refuge lies entirely within the town of Barksdale (population 723) and six miles west of the city of Ashland (population 8,216), which is the largest city in the region. Bayfield County has a total area of 1,478 square miles (946,000 acres). Nearly 50 percent of the land is publicly owned or controlled, including county, state, and federal forests, parks, and fish and wildlife areas (Bayfield County, 2010).

About 86 percent of county residents are white, and 10 percent are American Indian. About 18 percent of residents are under the age of 18, and 22 percent are over 65 years of age. The median age of Bayfield County residents increased by 17 percent between 2000 and 2010 and probably will continue to increase. More than 90 percent of the population 25 years or older has at least a high school level of education; 27 percent has a Bachelor's degree or higher (U.S. Census Bureau, 2013).

Logging, mining, and agriculture were the basis of the first period of rapid growth in northern Wisconsin in the late 19^{th} century. With the subsequent decline of these extractive industries came declines in population. In Bayfield County, the population has never again reached the peaks attained by 1920, although the rise of the tourism and recreation industry in recent years has brought new growth. According to recent census data, more than 40 percent of homes in the county are recreational (Bayfield County, 2010).

Income, Employment, and Local Economy

Median household income in Bayfield County is just over $44,000; about 13 percent of the population has income below the poverty line. The November 2014 unemployment rate in Bayfield County was 9.2 percent, compared to 5.2 percent for the state of Wisconsin. Leisure and hospitality is the largest employing sector in the county even on an average annual basis, despite the high degree of seasonality during the fall and winter months. Prominent Bayfield County employers include Red Cliff Band of Lake Superior Chippewa, County of Bayfield, Legendary Waters Resort and Casino, Northern Lights Health Care Center, and the school districts of Bayfield and Washburn (Michels, 2011; Wisconsin Department of Workforce Development, 2013; U.S. Department of Labor, 2015).

Agriculture

In 2012, Bayfield County had 352 farms totaling 72,000 acres. Market value of agricultural products sold was $13.9 million, about one-third from crops and two-thirds from livestock/poultry. Harvested crops included about 25,000 acres of hay and other forage, 2,000 acres of corn, and between 250 and 800 acres each of barley, orchards, oats, soybeans, and wheat. Net income averaged $5,779 per farm. Forty-nine percent of operators had a primary occupation other than farming (U.S. Department of Agriculture, 2012).

Tourism and Recreation

Tourism and recreation is the largest industry in Bayfield County. Popular activities include hunting, fishing, bicycling, picnicking, watching wildlife, sightseeing, attending festivals and special events, camping, swimming, ATVing, and boating. In the winter, ice fishing, snowmobiling, and cross-country skiing are popular. Demand for most of these activities is expected to continue to grow, as is the number of seasonal and second homes (Bayfield County, 2010).

The county's peak population estimate for a single day in the summer of 2006 was 45,329, about three times the resident population. In addition to the 15,000 residents, this figure included 7,350 lodgers in hotels, motels, and campgrounds; almost 20,000 owners of seasonal homes; and about 2,300 one-day visitors (Bayfield County, 2010).

In 2012, visitors spent $38.5 million in Bayfield County, which supported about 600 jobs and contributed $5.3 million in state and local taxes. Bayfield County ranked 46^{th} out of 72 Wisconsin counties in tourism impacts. Neighboring Ashland County ranked 53rd, with $29 million in visitor spending (Wisconsin Department of Tourism, 2013).

Northern Great Lakes Visitor Center

The NGLVC stimulates rural economic development by attracting visitors to the area and then directing them out to public lands and area businesses. A recent University of Wisconsin report (Hokans et al., 2013) found that about 75 percent of the 125,000 annual visitors to the Center are not local residents of Bayfield or Ashland counties. These non-local visitors spent roughly $5.1 million in the two counties in 2012. This economic impact can be measured in terms of 84 local jobs and $1.6 million in locally accrued employee compensation. The operational budget of the Center contributes almost $725,000 to the regional economy each year in employee salaries, supplies and expenses, and maintenance and upkeep.

3.5 Cultural Resources

Area History

[From Wisconsin Cartographers' Guild (1998) and Milwaukee Public Museum (2013).]

Prehistoric

Nomadic hunter-gatherers were present in Wisconsin from the earliest generally accepted cultural period, the Paleo-Indian tradition, that began about 12,000 years ago as glaciers retreated northward. These hunter-gatherers roamed widely through the boreal forest of the Midwest in search of mastodon, wooly mammoth, and other resources.

The Archaic tradition evolved as the climate became warmer and drier and cool moist boreal forest gave way to deciduous forest and savanna. Efficient hunting and gathering cultures developed, gradually becoming more sedentary and exploiting local environments for food and tools. Groups of Archaic people, for example, hammered metal tools from copper deposits in the Upper Peninsula of Michigan. There is consistent evidence of ongoing trade and other forms of interaction during this period.

Human populations increased dramatically during the Woodland period, which began about 2,500 years ago. Climate was similar to today and a broad belt of mixed deciduous and coniferous forest stretched from Lake Superior to New England. Woodland cultures began to make pottery, store food, develop small villages, and cultivate plants, although the short growing season in the north made crops unreliable there. Hunting, fishing, and gathering remained important. In many parts of the Great Lakes, particularly northern Wisconsin, wild rice was a dietary staple.

Historic

The first recorded contact between Europeans and Great Lakes Indians occurred between 1534 and 1542 when Cartier of France explored the St. Lawrence River. The French soon established colonies, alliances, and a thriving fur trade that increased competition among tribes in the eastern Great Lakes. The Iroquois tried to seize control of the fur trade through a series of wars, forcing many tribes to flee westward. Among those that made their way to Wisconsin were the Potawatomi, Ojibwe, Sauk, Fox, Ottawa, Huron, Miami, and Mascouten. Most eventually left the area, but the Potawatomi and Ojibwe stayed on. The Ojibwe became key French allies in the north. They moved according to the seasons, fishing in summer, ricing in the fall, hunting, trapping, and ice fishing in the winter; and tapping maple syrup and spearfishing in the spring.

The British won control of all French possessions in Canada and the Midwest in 1763. Green Bay, La Pointe, and Prairie du Chien emerged as primary Wisconsin sites of the British fur trade. Growing U.S.–British conflicts, however, led to the War of 1812, and the British lost the region to the Americans in 1814. The American fur trade declined by the 1850s due to depleted beaver populations, Native American land cessions, and removal of tribes to reservations.

The Ojibwe ceded vast tracts of forest in northwestern Wisconsin and east-central Minnesota in the 1837 Treaty, allowing timber companies to begin cutting the extensive stands of white pine. The 1842 Treaty ceded lands rich in copper and iron in northeastern Wisconsin and the Upper Peninsula of Michigan, including the Chequamegon Bay area. The 1854 Treaty allowed the Ojibwe to live on four reservations at Lac du Flambeau, Bad River, Red Cliff, and Lac Courte Oreilles. Small reservations for the Mole Lake Sokaogon and the St. Croix Ojibwe were created in 1934. In keeping with the decentralized Ojibwe political tradition, each reservation has its own government.

Commercial logging grew rapidly in Wisconsin from the 1850s through the 1890s, encouraging settlement of the state's northern regions. Many lumber mills opened in Wisconsin, including the south shore of Chequamegon Bay. Between 1899 and 1905, Wisconsin led the nation in lumber production. The last stands of old growth pine in the state were harvested in the early 1930s.

As the timber industry declined, northern Wisconsin was touted as the ideal place to acquire cleared land and establish farms. Much of the logged area became farmland, but the short growing season, infertile soil, and poor economic conditions made farming difficult. Much of the land was declared tax delinquent by the 1940s and today accounts for many of Wisconsin's national, state, and county parks and forests. Nevertheless, agriculture is still an important land use in the Chequamegon Bay region, including the Whittlesey Creek watershed.

Lake Superior became accessible to large ships in 1855 with the opening of the Sault Sainte Marie canal. Duluth-Superior became a leading grain port by the 1870s, but the primary cargo soon shifted to iron ore mined in Wisconsin, Michigan, and Minnesota. Enormous ore docks were constructed in Duluth, Superior, and Ashland for shipping the ore to steel mills and manufacturing plants. By the 1930s, the Lake Superior iron ranges were producing two-thirds of the world's iron ore. The iron deposits were exhausted after peaking in the 1950s.

A modest commercial fishing industry on Lake Superior during the 19th century included the Bayfield-Apostle Islands region, which had an excellent natural harbor, little industrial development, and plentiful whitefish, herring, and lake trout. The Wisconsin fishing industry steadily declined after the 1930s due to overfishing, invasion of exotic species, and industrial development and pollution. Since the 1950s, Wisconsin has worked with other states and Canada on exotic species control, environmental regulation, and fish restocking programs.

Chequamegon Bay tourism began in the mid-1800s, notably for anglers pursuing the coaster brook trout of Lake Superior. The city of Ashland was a destination for anglers from Chicago and other Midwestern cities, who arrived by train at the Chequamegon Hotel. Today, the Great Lakes retain their attraction for recreational fishing and boating.

Refuge Cultural Resources

Twenty-two sites in Bayfield County have been placed on the National Register of Historic Places, but none of these properties is located within the boundaries of the Refuge. Thirteen buildings or farmstead complexes are within the approved boundary. One of these buildings may have been the home of Asaph Whittlesey, founder of Ashland, WI in 1860, and after whom the creek was named. Also within the proposed boundaries could be the site of the cabin built in 1664 by Pierre Esprit Radisson, a French fur trader and explorer. No National Historic Landmarks are located within the Refuge. No cultural resources investigations have been conducted on the Refuge (FWS, 1998).

Cultural Resources Management

Cultural resources (archaeological sites, historic structures, and Native American traditional cultural properties) are important parts of the Nation's heritage. The Service strives to preserve evidence of these human occupations, which can provide valuable information regarding interactions between individuals, as well as between early peoples and the natural environment. Protection of cultural resources is accomplished in conjunction with the Service's mandate to protect fish, wildlife, and plant resources.

The Service is charged with the responsibility, under Section 106 of the National Historic Preservation Act of 1966, of identifying historic properties (cultural resources that are potentially eligible for listing on the National Register of Historic Places) that may be affected by Service actions. The Service is also required to coordinate these actions with the State Historic Preservation Office, Native American tribal governments, local governments, and other interested parties. Cultural resource management in the Service is the responsibility of the Regional Director and is not delegated for the Section 106 process when historic properties could be affected by Service undertakings, for issuing archaeological permits, and for tribal involvement.

The Archaeological Resources Protection Act of 1979 (ARPA) Section 14 requires plans to survey lands and a schedule for surveying lands with "the most scientifically valuable archaeological resources." This Act also affords protection to all archeological and historic sites more than 100 years old (not just sites meeting the criteria for the National Register) on federal land and requires archeological investigations on federal land be performed in the public interest by qualified persons.

The Regional Historic Preservation Officer (RHPO) advises the Regional Director about procedures, compliance, and implementation of these and other cultural resource laws. The actual determinations relating to cultural resources are to be made by the RHPO for undertakings on Service fee title lands and for undertakings funded in whole or in part under the direct or indirect jurisdiction of the Service, including those carried out by or on behalf of the Service, those carried out with federal financial assistance, and those requiring a federal permit, license, or approval.

The responsibility of the Refuge Manager is to identify undertakings that could affect cultural resources and coordinate the subsequent review process as early as possible with the RHPO and state, tribal, and local officials. Also, the Refuge Manager assists the RHPO by protecting archeological sites and historic properties on Service managed and administered lands, by monitoring archaeological investigations by contractors and permittees and by reporting ARPA violations.

3.6 Refuge Programs

Biological

Fish and Wildlife Restoration and Management

Coaster Brook Trout

In response to the significant decline in brook trout numbers, and in support of the *Brook Trout Rehabilitation Plan for Lake Superior* (Newman et al., 2003) and the *Wisconsin Lake Superior Basin Brook Trout Plan* (2005) the Service and WDNR are implementing an experimental restoration plan specific to Whittlesey Creek aimed at establishing a self-sustaining population of migratory brook trout.

The Brook Trout Rehabilitation Plan for Lake Superior (Newman et al., 2003) was adopted by the GLFC as a guidance tool for brook trout initiatives undertaken by management agencies situated around Lake Superior. The *Wisconsin Lake Superior Brook Trout Plan,* developed jointly by the WDNR and the Service (WDNR and FWS, 2005), builds on the lake-wide plan and names five priority Wisconsin tributaries for brook trout restoration: Brule River, Bark River, Raspberry River, Whittlesey Creek, and Graveyard Creek. Overall program objectives address stream and watershed health, harvest, stocking, genetics, life history, species interactions, and outreach. Restoration and management actions are tailored to individual streams. An interagency team holds regular coordination meetings to evaluate progress and address any issues that arise.

The Whittlesey Creek experiment is the only brook trout restoration program in Wisconsin's Lake Superior basin that combines all four of the following actions:

A. Improve Habitat
B. Establish Protective Harvest Regulations
C. Stock Coaster Brook Trout
D. Assess and Monitor

A. Improve Habitat
Refuge staff has responsibility for the habitat improvement portion of the Whittlesey Creek experiment. Several hydrologic and geomorphic studies have been completed that identify watershed and in-stream stressors affecting brook trout habitat in Whittlesey Creek (WDNR et al., 1996; Trout Unlimited 2003; WDNR and FWS, 2005). Implementation of a detailed HMP for

Whittlesey Creek is now underway (FWS, 2006c). The plan includes long-term restoration objectives and strategies for the Refuge, the stream, and the watershed.

B. Establish Protective Harvest Regulations

The WDNR changed angling regulations in 2003 to provide greater protection for brook trout during this experiment. Whittlesey Creek now is a "catch and release only" stream for brook trout. In addition, regulations for brook trout harvest in Lake Superior now include a 20-inch minimum size limit and one fish per day bag limit. These regulations are intended to continue for the length of the experiment.

C. Stock Coaster Brook Trout

Stocking brook trout into Whittlesey Creek has occurred frequently over the last 100 years (FWS and WDNR, 2003). No record exists of the strains used but it is generally understood that, until the 1990s, the source fish were not from the Lake Superior basin. In addition, most early stocking efforts were not accompanied by habitat restoration, protective regulations, or monitoring.

All brook trout now stocked in the basin come from strains that originated in the basin and that were known to use the lake environment. For this experiment, two strains (Tobin Harbor and Siskiwit) from Isle Royale, Michigan were stocked between 2004 and 2009. Life stages used were eyed eggs, fingerlings (1–2"), yearlings (4–5"), and adults (>8"). All life stages (except eggs) received a mark for later identification. Iron River and Genoa National Fish Hatcheries raised the fish and the Ashland Fish and Wildlife Conservation Office (FWCO) released them into Whittlesey Creek. Table 3-3 shows number, life stage, and year stocked.

Table 3-3: Whittlesey Creek Brook Trout Stocking

	2003	2004	2005	2006	2007	2008	2009
Egg		50,000		50,000		50,000	
Fingerling			20,000		20,000		20,000
Yearling		2,000		2,000		2,000	
Adult	75		50		50		50

D. Assess and Monitor

The Ashland FWCO is responsible for the assessment and monitoring portion of the Whittlesey Creek brook trout experiment. Four stream reaches were selected as index stations to be sampled each fall throughout the experiment. Pre-stocking, baseline data were collected from 2001–2003 at the four fixed index stations, and is scheduled to continue at least through 2030 to evaluate brook trout reproduction, recruitment, and survival over time.

Pre-Stocking – The 2001–2003 pre-stocking data showed an estimated 70 to 80 percent decline in brook trout numbers compared to a comprehensive survey conducted by the WDNR in 1977, confirming the need to begin an experiment to better understand what conservation and management actions are potentially needed in order to restore a coaster brook trout population. The significant decrease in brook trout numbers from 1977 to the early 2000s was possibly due to habitat changes caused by flooding during the 24 years between surveys. Coho salmon far outnumbered brook trout in all three years of baseline, pre-experimental phase monitoring. Population estimates of all trout and salmon collected during the pre-stocking phase are shown in Table 3-4.

Table 3-4: Whittlesey Creek Fall Trout Population Estimate by Year

	Young-of-year Coho*	All Rainbow*	All Brown*	All Brook
Pre-stocking Phase				
2001	1,796	78	67	68
2002	5,181	670	1,300	68
2003	18,796	1,210	79	101
Stocking Phase				
2004	6,438	4,254	57	209
2005	12,049	4,717	34	1,479
2006	6,513	3,327	37	428
2007	14,188	4,485	40	1,049
2008	8,660	3,302	46	614
2009	14,762	1,678	72	546
Post-stocking Phase				
2010	17,650	1,372	38	413
2011	12,961	2,086	63	244
2012	8,966	1,259	49	152
2013	5,279	780	30	170

Asterisk * indicates non-native species

Stocking – Annual fall surveys of the four fixed stations were completed throughout the timeframe when stocking was being conducted (2004–2009). As to be expected during a period of regular stocking, overall brook trout numbers increased, as did the frequency of occurrence of multiple life-stages. In some years, the overall brook trout population was 10 times higher than any of the three years pre-stocking.

Post-Stocking – The post-stocking evaluation phase began in 2010 and continues to present. In comparing the past four years of catch data (2010–2013) to that of the pre-stocking baseline (2001–2003), at least three-year classes of brook trout are present. The average number of adult (age 2+) brook trout in Whittlesey Creek represents a ten-fold increase compared to that of the pre-stocking phase. The average number of yearlings (age 1) and young-of-year brook trout over the past four years represents a two-fold increase.

Life-Stage Comparison – A thorough evaluation of the contribution that each life stage stocked has made to the existing brook trout population is not yet complete. However, preliminary results indicate that of the four life-stages stocked (i.e., eyed-eggs, fingerlings, yearlings, and adults), fingerlings appeared to have the highest survival rate to the yearling, and subsequent adult stage. Survival of adult brook trout stocked was quite low, and based on telemetry and Passive Integrated Transponder (PIT) tag data of stocked adult fish, most adults either died (e.g., predation) or emigrated out of Whittlesey Creek <30 days post stocking. Due to vandalism in two of the three years of eyed-egg stockings, an accurate and thorough evaluation of this stocking strategy is not possible.

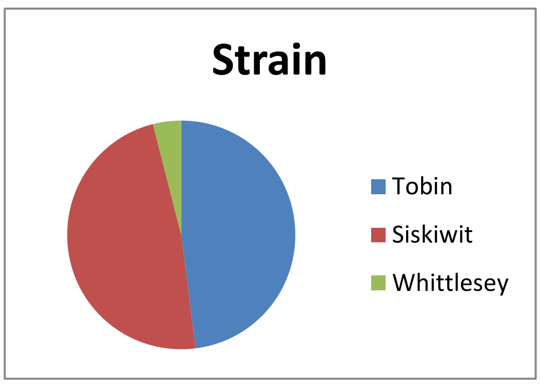
Comprehensive Fish Community Surveys – In addition to the annual surveys of the four index stations, Ashland FWCO and WDNR conducted comprehensive fish surveys of Whittlesey Creek from mouth to headwaters in 2001 (pre-stocking) and 2010 (immediately post stocking), replicating a 1977 survey completed by the WDNR. The purpose of the comprehensive survey is to obtain a more complete survey of the fish community across a broader spatial scale than what is obtained from the annual index survey of four sites. Table 3-5 shows estimates of the total number of brook trout collected at six comparable sites across the three years when comprehensive surveys have taken place. Comprehensive fish surveys of Whittlesey Creek to assess the entire fish community are scheduled for completion every 10 years through 2030.

Table 3-5: Whittlesey Creek Comprehensive Brook Trout Surveys

1997	2001	2010
184	56	413

Genetic Strain Comparisons – To establish a genetic baseline for the brook trout population that existed in Whittlesey Creek prior to the stocking phase of the experiment, tissue samples (i.e., small fin clip) were taken from fish collected from 2001–2003. During and following the stocking phase, tissue samples were taken from brook trout collected during annual assessments. Tissue samples were analyzed and assigned by the U.S. Geological Survey (USGS) Great Lakes Science Center (2004 and 2005) and the Service's Northeast Fishery Center (2006–2010) to one of three strains: Whittlesey Creek, Tobin Harbor, or Siskiwit. To date, tissue samples from brook trout collected during fall assessments from 2004–2010 have been processed. Annual and life stage variations exist with respect to strain performance, but overall it appears that the Tobin and Siskiwit strains perform equally well. Also, the Whittlesey Creek baseline population continues to be present, but in a much smaller proportion (Figure 3-10).

Figure 3-10: Genetic brook trout strains in Whittlesey Creek



Emigration/Immigration – In addition to annual monitoring of the fish community in Whittlesey Creek, a solar-powered, remote PIT tag reader was installed near the mouth of Whittlesey Creek in the spring of 2008 to monitor emigration and immigration of coaster brook trout. PIT tags were/are inserted into the abdominal cavity of all brook trout captured > 5 inches that were either stocked or collected since 2008. Eighty-nine of the 2,000 yearlings stocked in spring 2008 were subsequently detected leaving Whittlesey Creek, mostly in the spring and fall between 10:00 p.m. and 2:00 a.m. Five of the 89 have since returned to Whittlesey Creek—one in fall 2009, one in spring 2010, and three in fall 2010. Movement of brook trout originally stocked or collected in Whittlesey Creek into other streams also has been documented. Additional analysis will be completed as more data become available.

Progress Toward Goal – The overall goal of this project is to establish a self-sustaining brook trout population that exhibits a migrating life history by 2030. A population is considered self-sustaining when it supports itself via 25 breeding pairs for at least two generations after stocked fish no longer contribute to recruitment. To date, we have not achieved this goal, nor did we expect to as a sufficient amount of time post stocking has not taken place. However, all indications based on survey results to date indicate that significant progress toward achieving our goal has been made, and that the strategies identified in the experimental plan (see appendix H) should continue. We have observed a 2–10 fold increase in the number of fish present (depending on age-class), we continue to observe annual reproduction as witnessed by our collection of young-of-the-year fish in the fall, we have observed large (relative to pre-stocking) numbers of adults, and the genetics are telling us that coaster brook trout strains used during our stocking phase are performing well. Last, but certainly not least, we have documented a small percentage of the brook trout in Whittlesey Creek exhibiting migratory behavior, emigrating from Whittlesey Creek as young, immature fish returning subsequently as adults, presumably to spawn.

Habitat Restoration and Management

The HMP for Whittlesey Creek NWR has provided direction and guidance for Refuge habitat activities since 2006. The HMP includes objectives and strategies both for lands within the Refuge boundary and for upstream private lands within the Whittlesey Creek watershed, organized under four general goals (FWS, 2006c):

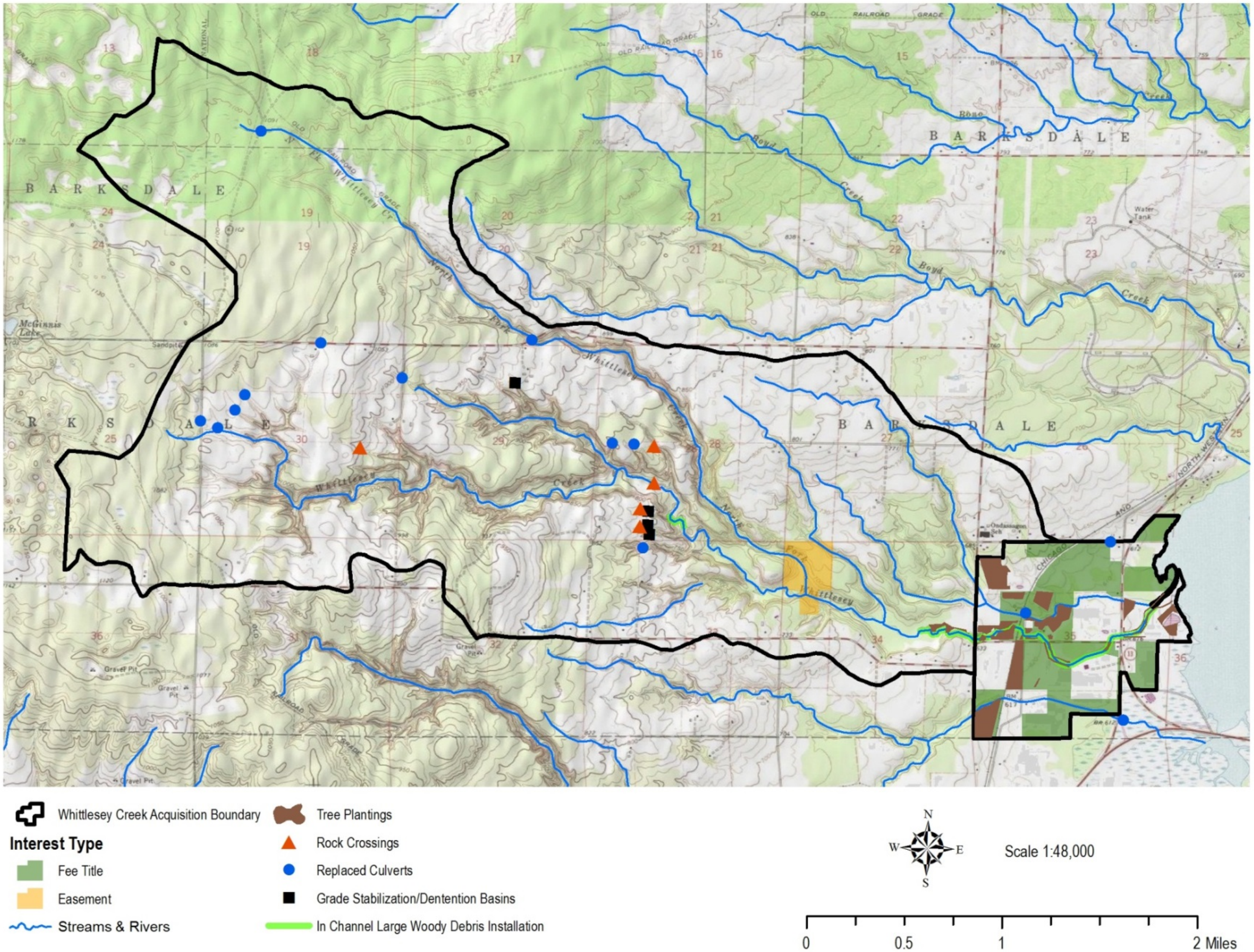
1. **Stream**: Restore watershed and stream hydrologic functions that improve fish and wildlife habitat within the stream and the Refuge, with an emphasis on native species.
2. **Sediments**: Reduce sediment loads into Whittlesey Creek to historic (pre-European settlement) range of variability.
3. **Floodplain and wetland hydrology**: Restore to the extent possible floodplain function in the coastal wetlands and floodplains of the Refuge.
4. **Floodplain habitat**: Restore native species composition of trees and shrubs in the floodplain that will provide heterogeneous vertical and horizontal structure for migratory bird habitat.

The USGS studied the effects of land cover on flooding and base flow characteristics of Whittlesey Creek by use of two groundwater flow models (GFLOW and MODFLOW) and one rainfall runoff model called the Soil and Water Assessment Tool (SWAT) (Lenz et al., 2003). The study was done in cooperation with the Bayfield County Land and Water Conservation Department (LWCD) and the Service. GFLOW and MODFLOW showed that the groundwater contributing area did not coincide with the topographically delineated surface-water-contributing basin. Instead, about 90 percent of the base flow to Whittlesey Creek originated as recharge through the permeable sands in the center of the Bayfield Peninsula. The SWAT model indicated that changes in land cover within the surface-water-contributing basin would have minimal effects on average annual runoff for Whittlesey Creek but would affect flood peaks. The predicted reduction of flood peaks under more forested conditions could potentially cause a reduction in sedimentation near the mouth of Whittlesey Creek.

Additional information comes from a Sediment Impact Analysis Methods (SIAM) model for the Whittlesey Creek watershed developed in partnership with the USACE and USGS (USACE, 2010). The Whittlesey Creek model was developed to screen various restoration options and determine potential impacts to the sediment balance. Four scenarios were initially modeled: addition of large woody debris, reduction in peak flows in the upper reaches, floodplain reconnection in the lower reaches, and bank stabilization in the mid-upper reaches. SIAM found that restorations that affected hydraulics had the most significant effects on the sedimentation and erosion dynamics of the system. SIAM also found examples of potential unintended consequences of restoration to the sediment regime of downstream reaches. This tool can help focus restoration efforts and funding on the most feasible projects that have the greatest chance for long-term restoration success.

Recent habitat restoration activities have centered on in-stream habitat and fish passage, although progress on floodplain, wetland, and watershed restoration also has been significant (Figure 3-11).

Figure 3-11: Habitat Restoration Projects to Date



Stream

Large Woody Debris

When the Refuge was established, large woody debris had been nearly eliminated from stream channels. By 2014, more than 600 logs will be added to the lower 2.5 miles of Whittlesey Creek, slowing flood flows, protecting stream banks, providing cover for fish and invertebrates, and exposing beneficial gravel that had been buried in sediment. This portion of the creek lies mostly within the authorized Refuge boundary and was one of the most highly degraded channel segments based on quality of fish and invertebrate habitat. Many of the restoration sites are easy to access and highly visible, making them good demonstration areas for the benefits of large woody debris.

Large woody debris installation.

Another 120 logs were installed upstream near the North Fork confluence where year round base flow in Whittlesey Creek begins. This project was designed primarily for bank/bluff stabilization and erosion control rather than fish habitat but, like the downstream installations, it serves both functions. No logs have been installed yet on Little Whittlesey or Terwilliger Creeks.

Logs are installed in clusters using a large track excavator—either by placing them in trenches and backfilling, or by pushing them into the bank. Logs are cabled together and made to look like natural logjams. Contractors handle design, engineering, construction oversight, and log placement.

Northland College students, volunteers, staff from agency partners, the Youth Conservation Corps, and Refuge staff assist with cabling, seeding, and mulching. Refuge staff and contract engineers jointly determine the best locations and configurations for log clusters along the creek based on channel profile data, site visits, and professional experience. Funding has come from many sources including National Fish and Wildlife Foundation, WDNR, Bayfield County LWCD, Trout Unlimited, Great Lakes Restoration Initiative, and the FWS Partners for Fish and Wildlife program.

In-stream habitat monitoring is based on the Fish Habitat Rating System (Simonson et al., 1993) developed specifically for Wisconsin streams. The system gives a qualitative ranking (poor to excellent) of habitat suitability for coldwater fish based on measures such as channel width and depth, cover, pool area, channel substrate, and riparian buffer width. Pre-restoration data is available for 21 reference sites established in the Whittlesey Creek watershed; post-restoration data is collected by the Youth Conservation Corps (YCC) at sites that are influenced by large woody debris installation. Refuge staff is especially interested in documenting changes in channel width, depth, and substrate and thalweg depth and substrate. Results at two restored sites with good before and after data showed significant increases in average water depth and percent gravel substrate within one year of log placement (Marx, 2012). These changes indicate exposure of potential spawning substrate and improved rearing habitat for anadromous fish, including coaster brook trout.

Northland College students and Refuge staff help collect and analyze data on diversity and abundance of macroinvertebrates and fish before and after log installation. Data from the initial round of sampling show some promising signs, although a more detailed analysis is needed. The initial data has documented the invertebrate families present using samples from treatment and reference sections of the creek. The study confirmed that the addition of logs resulted in an increase in caddisfly larvae of the *Limnephilidae* family. *Limnephilidae* are often clingers that depend on larger rocky substrates for a place to cling while they wait for food to drift past. Long-term data collection may help document a shift in invertebrate communities as the habitat changes. Exposure of gravel substrates, creation of deeper pools, and increased surface area on logs in the stream are expected over time (Brunk, 2012).

Brook trout and rainbow trout have been documented using the newly created habitat, with anecdotal sightings of coho salmon, too. A longer data record is needed, however, before observed increases in fish use of restored cover, pools, and backwaters can be confirmed statistically. Refuge staff and Northland College professors plan to collect annual datasets on fish and aquatic macroinvertebrate abundance and diversity, as well as fish habitat rating for a minimum of five years post-log installation.

Culverts and Bridges

The Service and its partners have replaced fourteen road culverts in the Whittlesey Creek and Terwilliger Creek watersheds since the Refuge was established, increasing fish access to spawning habitat along about five miles of the creek. Nearly every replaced culvert has had dual benefits for stream health—improving fish passage and reducing scour and stream bank erosion. Culvert replacement also benefits local communities by reducing road flooding, washouts, and maintenance costs. Local support for the program is very strong. Several culverts still need replacement in intermittent stream reaches, along forest roads, and on Terwilliger Creek.

A well-designed culvert installation allows enough water flow at the right velocity to facilitate fish movement through it. The Bayfield County LWCD designs the new Whittlesey Creek installations, considering watershed size, flood flows, and stream alignment. Proper pipe diameter and length are important. Smaller culverts are cheaper, but undersized culverts can increase water velocity, which inhibits fish passage and increases erosion potential. The slope of the new culverts is no more than one percent and alignment is consistent with natural stream alignment. The lower 12 inches of culverts are embedded in the channel substrate to establish a natural streambed through the pipe.

Poorly designed culvert.

Well-designed culvert.

All of the bridges that cross Whittlesey Creek are too narrow and should be replaced. Narrow bridges cause downstream scour and bank erosion and create upstream backwaters that accumulate sediment. One bridge on the Refuge constricts the channel by 50 percent and is a very high priority for replacement as soon as funding becomes available. It is scheduled for replacement during 2015.

Floodplain and Wetland

Tree Planting

Trees are planted on and near the Refuge to restore the historic forest cover that will slow floodwaters, stabilize stream banks, contribute large woody debris to the stream system and forest floor, and improve habitat for fish, migratory birds, and other wildlife. The first tree planting was in 2003 as part of the National Wildlife Refuge System (NWRS, Refuge System) centennial celebration. Since then, about 60 acres total have been planted—mostly on Service fee title land, but also on some Refuge inholdings and adjacent private land.

Trees are planted in riparian zones along Whittlesey Creek, in floodplain hayfields, and on the limited upland areas. Riparian plantings occur in the same stream reaches as large woody debris restoration, usually in September when log placement is complete and weather is cooler. Hayfield plantings occur more often in spring, shortly after the frost is gone. Priority fields for planting are those that will fill gaps in forest cover, reducing habitat fragmentation.

Refuge staff uses a suite of native conifers—typically red pine (*Pinus resinosa*), white pine (*Pinus strobus*), white spruce (*Picea glauca*), and sometimes black spruce (*Picea mariana*). Tamarack, northern white cedar, and eastern hemlock (*Tsuga canadensis*) sometimes are used in lower wetter locations. Conifers are preferred based on easy availability, fast growth, and less deer browse compared to hardwoods. Conifers also are more effective than deciduous trees at slowing the flow of floodwater. Planting assistance has come from Northland College students, other volunteers, the Conservation Corps Minnesota and Iowa, Trout Unlimited, and a local tree care service.

Newly planted trees.

Planting techniques have been refined over time. Two-year-old accelerated growth transplants are now the preferred planting stock. Accelerated growth transplants have extensive fibrous root systems, are more resistant to drought, absorb nutrients from a larger volume of soil, are more competitive with existing vegetation, grow faster in the first few years, and survive much better than the bare root or tap root trees used previously. No monitoring data is available on tree survival and growth or migratory bird use, but field observations indicate that survival of the accelerated growth transplants has been well over 75 percent so far. Annual deer repellent application on browse-susceptible species is critical until growth exceeds browse height. Aspen trees are sometimes felled along field margins to promote suckering, natural succession, and forest diversity.

Invasive brush (mostly buckthorn and honeysuckle) is controlled prior to tree planting when necessary. Trees are planted using planting bars and roots are pruned as needed to fit easily into each hole. Species are randomized across the landscape but selected for each microsite based on soil moisture and soil type. Tamarack and northern white cedar prefer wetter areas, for example, while red pine prefers higher warmer sites. White pine, northern white cedar, and eastern hemlock are especially susceptible to browse, so are cluster planted in groves of 20 to 25 trees to facilitate spraying with deer repellent. Every tree gets a slow release fertilizer tablet when planted. An average spacing of 12 feet by 12 feet is used to calculate the number of trees to order. Planning has begun to plant 60 acres during the spring of 2015 in partnership with the USFS with funding provided by the Lake Superior Landscape Restoration Partnership (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/wi/home/?cid=STELPRDB1247205).

Wetland Restoration

The Refuge and watershed historically contained many small shallow wetland basins that slowed runoff, trapped sediment, and provided habitat for wetland wildlife. Nearly all of these ephemeral wetlands were lost as fields were leveled and ditches dug to increase drainage and improve agricultural production.

Restored wetland.

Over fifty basins totaling approximately 20 acres have been restored within the Refuge's fee title and easement acquisition area. Approximately one-half are floodplain wetlands on Refuge lands and inholdings. The Refuge, FWS Partners for Fish and Wildlife Program, Bayfield County LWCD, and the Wisconsin Priority Watershed Program have provided funding for wetland restoration projects. Refuge staff uses leaf-off aerial imagery to delineate naturally occurring basins and manmade drainage systems. Groundwater and red clay typically can be found five to eight feet or less below the floodplain, so many wetlands were restored simply by plugging the ditches that drained them. Some larger basins were excavated and dikes pushed up during restoration to hold more water. Many of the smaller basins installed during the Wisconsin Priority Watershed Program are now covered with cattails and filling with decayed vegetation. Excavation would improve structure and function since water deeper than three feet in wetlands typically does not become colonized by cattails. Water control structures have not been installed and no active water management occurs. Disposal of some spoil material, placed in the Refuge floodplain during proposed golf course development, is still needed.

No formal monitoring of wetland vegetation occurs on the Refuge. The restored wetlands are expected to provide habitat for nesting waterfowl, marsh birds such as American bittern and green heron, and other wetland wildlife, although no breeding season surveys are conducted to document wildlife use. Partnerships with Northland College professors have the potential for establishing long-term monitoring.

Watershed

A healthy Whittlesey Creek watershed is important for successful restoration of Refuge lands downstream and successful reintroduction of coaster brook trout in the creek. The Service has authority to purchase up to 1,260 acres of conservation easements from willing landowners in the watershed. Service staff also works with private landowners and other partners to design and implement voluntary farm conservation practices that slow overland flow and reduce erosion.

Conservation Easements

Two conservation easements totaling 47 acres have been purchased from private landowners so far. Each easement includes a permanent agreement between the landowner and the Service that sets forth specific restrictions on development and land use. Easements allow the landowner to continue many outdoor recreation uses on their property including hunting, fishing, walking, and quiet enjoyment. Through the easement, motorized uses or consumptive activities are restricted. Landowners do not have to allow public access through the easement. The property also remains on the tax rolls, limiting the impact to local governments. The first easement agreement was not very restrictive; subsequent agreements placed more restrictions on land use and gave the Service more management rights.

Landowners receive payment for the appraised value of their easements. Early participation in the Whittlesey Creek program has been low, but reinterpretation of the legal authority for these easements has increased the appraised values, which is expected to increase landowner interest.

Farm Conservation Practices

Rock stream crossings and detention basins are two techniques that have been used on private lands to improve the health of the Whittlesey Creek watershed. Rock crossings stabilize banks and the streambed on perennial and intermittent drainages. Several have been constructed in the watershed to minimize erosion while allowing farm machinery to cross. Detention basins help keep nutrients and sediment out of the creek. They slow runoff from farm fields and livestock operations, absorb nutrients, and allow solids to settle out before the water reaches drainage ditches and ravines. Landowners also work with the Service to implement other conservation measures on their property including culvert replacement, in-stream log installation, wetland restoration, and tree planting.

Invasive Species

Buckthorn (*Rhamnus cathartica*) and reed canarygrass (*Phalaris arundinacea*) are currently the invasive species of highest concern that are known to be present on the Refuge. Buckthorn is most common in riparian areas, along fencerows, and in old hayfields transitioning to shrubs. Dense thickets of box elder dominate some areas. Common tansy (*Tanacetum vulgare*) is primarily found in areas that were altered during development of the proposed golf course. Knapweed (*Centaurea sp.*) is also present along roadsides and on the abandoned railroad grade that cuts through the Refuge. Buckthorn and other invasive woody plants are treated in fields and riparian areas as necessary prior to tree planting by applying glyphosate to cut stumps or girdled trunks. Prescribed fire would reduce the reed canarygrass that is dominant along the edges of floodplain sedge meadows, but treatment has been minimal due to limited resources. Burning is being proposed prior to the 2015 60-acre tree planting that was discussed previously. Previous coastal wetland purple loosestrife (*Lythrum salicaria*) infestations have effectively been suppressed by releasing *Galerucella spp.* beetles.

Partners in the NGLVC established an Invasive Free Zone in 2005 (defined as a 95 percent reduction of net infested acres for individual invasive species) to achieve a monitoring and maintenance mode for invasive plants and to restore native vegetation within the boundaries of the Refuge and NGLVC. Major components of the concept included comprehensive inventory and monitoring, control of all known invasives, demonstration of lessons learned, and outreach and education beyond project boundaries. A management plan (McNamara and Mlynarek, 2007) and guidebook (McNamara, 2007) for the project were completed in 2007 (McNamara and Mlynarek, 2007). Seven high priority invasive plants were chosen based on their relative abundance and relative invasiveness. Initial support was obtained for inventory, mapping, and control efforts, but national funding priorities shifted over time and the program has not been active for several years. Treatment, primarily of woody invasives, occurs intermittently as training opportunities for the National Park Service Exotic Plants Management Team and on a contract basis with Conservation Corps Minnesota and Iowa. Buckthorn and honeysuckle control is being planned for 2015 with the USFS via Lake Superior Landscape Restoration Partnership funding.

The Northwoods Cooperative Weed Management Area provides a forum to share information and resources, collaborate on planning, and cooperate on invasive species management in Douglas, Bayfield, Ashland, and Iron counties in northern Wisconsin. Supporters include state and federal agencies (including Whittlesey Creek NWR), municipalities, tribes, nonprofits, community organizations, and individuals. Recent projects have included shoreline restoration in the city of Ashland, inventory of invasive plants along town and county roadsides, and treatment of invasive plants in gravel pits that otherwise could spread seed to other locations.

Inventory, Monitoring, and Research

A separate inventory and monitoring plan is being developed that will help identify priorities. A general description of current inventory, monitoring, and research efforts follow and many of these are the result of Refuge HMP recommendations.

On-going fish survey efforts are led by the FWS Ashland Fish and Wildlife Conservation Office. Annual September mark and recapture sampling is conducted within four index stations. Refuge staff, volunteers, and WDNR participate. Details appear in Section 3.6, D. Access and Monitor, above, and in appendix H: Whittlesey Creek Brook Trout Experiment. Additionally, to document the effects of in-channel habitat restoration, Refuge staff, YCC, and Northland College professors and students collected mark-and-recapture fish population data pre-log installation and plan to continue for a minimum of five years post-installation.

Aquatic macroinvertebrate population diversity and abundance surveys were initiated pre-log installation and it is anticipated that they will be continued for a minimum of five years post-installation. Refuge staff, YCC, and Northland College professors and students participate.

Twenty-one in-stream habitat monitoring reference sites have been established in the Whittlesey Creek watershed. Monitoring protocol measures characteristics such as channel width and depth, cover, pool area, channel substrate, and riparian buffer width, and provides a qualitative ranking (poor to excellent) of habitat suitability for coldwater fish. Data track changes to individual metrics as well as overall qualitative ranking pre- and post-management activity. Activities include log-installation or culvert replacement, for example. Refuge staff and YCC annually complete this monitoring on a subset of the twenty-one sites.

A cooperatively funded USGS stream gaging station is located about one mile upstream from the mouth of Whittlesey Creek. Gage readings are posted at http://waterdata.usgs.gov/nwis/uv?040263205. Funding is provided by the Refuge, Ashland Fish and Wildlife Conservation Office, Bayfield County LWCD, and USGS. The gage has been operational since April 1999. Data are used for the SIAM model that consultants rely on when engineering and designing practices such as in-channel log installations. Ideally, gage hydrographs will indicate that Whittlesey Creek is less flashy as watershed enhancement, restoration, and protection efforts proceed. USGS is responsible for all aspects of gage operation and maintenance.

Nighttime bat and bird monitoring via acoustic recording was initiated on the Refuge by Regional Office staff during 2014. Data will provide information about species presence and seasonal migration. Of particular interest is the northern long-eared bat (*Myotis septentrionalis*), currently proposed to be federally listed as endangered. Refuge staff provides the minimal required weekly maintenance.

Visitor Services

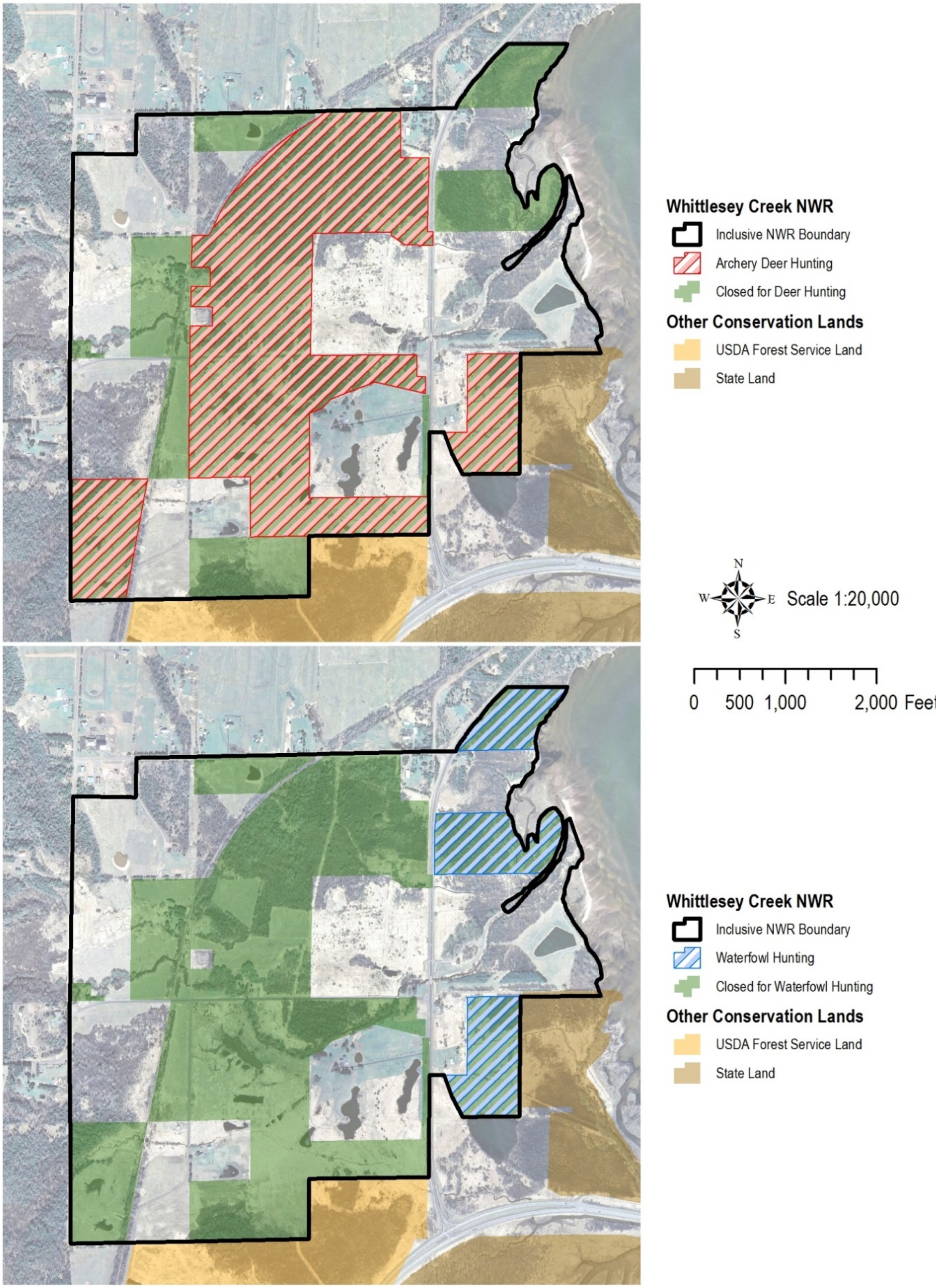
Hunting and Fishing

Archery deer hunting is allowed on the Refuge. Only tracts of land greater than 20 acres are open to hunting in an effort to avoid trespass issues with neighbors. Since safety is imperative, archery is not allowed near the Refuge Coaster Classroom or Visitor Center boardwalk adjacent to the Refuge. No Refuge-specific statistics are kept for number of hunters or number of deer harvested. The Refuge is managed as part of a deer management unit in the state of Wisconsin.

Waterfowl hunting is allowed east of Highway 13, an area that includes the shoreline of Chequamegon Bay in Lake Superior. The area is relatively small and mainly provides opportunities for shore hunting of diving ducks (Figure 3-12).

Fishing is not allowed pursuant to Refuge regulations but, according to state regulations, individuals can fish in Whittlesey Creek as long as they are able to access the creek at a legal point and stay within the creek to fish. Whittlesey Creek is a catch and release brook trout stream.

Figure 3-12: Refuge Hunting Areas



Wildlife Observation and Photography

Wildlife observation and photography are allowed on Whittlesey Creek NWR. Use varies during the year, peaking during special events at the NGLVC. Events such as the Chequamegon Bay Birding and Nature Festival in May attract birders from across the country, many of whom take advantage of Refuge programs held as part of the event. Chequamegon Bay and the associated shoreline of Lake Superior including the mouth of Whittlesey Creek offer excellent wildlife viewing opportunities. The Bay is an important migratory stopover for numerous waterfowl. The mouth of the creek is a gathering area for many migrant shorebirds, eagles, waterfowl, and other wildlife. The Refuge also provides habitat for migrating warblers, raptors, and other birds that use the Bayfield Peninsula as a staging area to cross Lake Superior.

Most of the opportunities at the Refuge are associated with roads or the Lake Superior shoreline since there is no developed trail system on the Refuge.

Environmental Education and Interpretation

Currently the park ranger position at the Refuge, which coordinates the environmental education and interpretation program, is being held vacant for cost savings. If filled in the future, the position will resume education and interpretation work in partnership with the NGLVC. The level of programming will be dependent on the funding provided for the position. The education program focuses on high quality programs that are tied to school curriculum and have on-Refuge and off-Refuge components.

Environmental education program.

The Refuge also has developed school-specific partnerships such as the “River of Words” program with the School District of Washburn. Through this program, Washburn fourth-graders understand what a watershed is, learn what is in their local watershed, and try new mediums to express their thoughts. The students develop a great sense of place, connection to nature, and a beginning sense of stewardship. They express what they learn through art and poetry with the help of a local artist and a local poet. Their expressions, connections, and enthusiasm spill out from every page and every project they complete during their fourth-grade year.

Interpretive programs on the Refuge and in partnership with the NGLVC will focus on wildlife or habitat related topics including duck calling contests, owls of the Northwoods, waterfowl identification, habitat restoration, and many others. Refuge programs complement the additional programs offered at the Center by other partners, which cover a wide range of topics from cultural, historic, geo-caching, local history, etc. The varied programs are representative of the various agency priorities for their individual interpretive and educational themes. For example, Service priorities are wildlife, habitat, and wildlife-dependent recreation while agencies such as the USFS have a broader mission that places more emphasis on consumptive use.

Coaster Classroom.

The Refuge maintains the Coaster Classroom, a 576 square foot screened-in classroom available for programs. The classroom is near a Refuge parking lot and overlooks a wetland adjacent to Whittlesey Creek. The classroom is located about two miles from the NGLVC.

The Refuge biologist is actively involved in educational efforts at the Refuge, participating in special events including the Birding and Nature Festival. This three-day event hosted at the Center attracts over 400 birders who enjoy programs throughout the lower Chequamegon Bay area. Several of these programs are on Refuge lands. The Refuge participates in other programs such as Kid's Fishing Day if they have a tie to the mission of the Service.

Northland College students often collaborate with the Refuge biologist for internships, completion of Senior Theses, or short volunteer terms to gain useful experience. The Refuge biologist not only acts as a guide for useful projects but also serves as a mentor to the students. The biologist provides inventory, monitoring, sampling techniques, and habitat restoration experiences to students and YCC crewmembers.

Outreach

Outreach efforts include educational opportunities related to the habitat restoration and management program. The current level of outreach for the Refuge is limited by available staff time. Various techniques have been used in the past to provide information about the Refuge to the public including Facebook, watershed newsletter, news releases, and mailings to neighbors. The Refuge also benefits from the extensive outreach completed by the NGLVC partnership. The Center maintains a website and Facebook page, both of which list Refuge programs through the partnership.

The Refuge biologist hosts several outreach programs each year including a tour of watershed projects for agency and non-profit partners and the public. The tour is a good opportunity to highlight projects and continue to engage the public and partners in the Whittlesey Creek restoration program. Since Whittlesey Creek is the site of an experimental restoration program for coaster brook trout, the extensive data collection and analysis program, habitat restoration projects, and history of fish stocking provide a great opportunity to tell the story of a comprehensive habitat and species restoration program.

Volunteers

The Refuge works with numerous volunteers to help with habitat surveys, restoration efforts, public use projects, and general maintenance. Many volunteers are students at Northland College pursuing degrees in various biological and natural resources disciplines. Students volunteer at the Refuge to gain practical experience.

Partnerships

Partnerships are the key to just about every project the Refuge completes. Partners range from agencies at the NGLVC to many agencies and organizations in the local community. The Refuge works closely with the Ashland Fish and Wildlife Conservation Office on the coaster brook trout restoration program. The Fisheries and Aquatic Resources program within the Service is responsible for coordinating the restoration project, while the Refuge takes the lead on the habitat restoration portion.

The Refuge maintains strong relationships with the town of Barksdale and Bayfield County. The restoration of coaster brook trout is a comprehensive program that combines stocking and regulations with watershed restoration. Since the Refuge is a relatively small portion of the watershed, it is important to work closely with many partners to restore the watershed. Important project elements include culvert replacement, bank and bluff stabilization, and in-stream habitat. The success of the project depends on the Refuge’s partnerships with local government units, landowners, and local agencies. The Refuge has a strong partnership with the Bayfield County LWCD. The LWCD coordinates many of the projects including technical support, grant submission, fiscal management, and project oversight. Since the Refuge is a relatively small portion of the project area, these partnerships are crucial for success.

Northern Great Lakes Visitor Center Partnership

The Service is one of six partners at the NGLVC. The Center’s mission is “The Northern Great Lakes Visitor Center helps people connect with the historic, cultural, and natural resources of the Northern Great Lakes Region through customer-based information, services, and educational programs.” The general direction of the Center is managed through the Center’s Board of Directors, which consists of one representative from each agency at the Center and a representative from the Friends of the Center Alliance, the Center’s non-profit 501(c)(3) friends group. The partner agencies include USFS, National Park Service, FWS, University of Wisconsin Extension, and the Wisconsin Historical Society. The Board sets direction for the Center and manages the common cost budget for the facility.

The Whittlesey Creek NWR office is located in the Center, and the Refuge, through the partnership, is able to use the classrooms, common areas, and administrative facilities to support the Refuge mission. The Refuge also has an exhibit located in the Visitor Center that acquaints visitors with the mission of the Refuge System and tells the story of Whittlesey Creek NWR. There are numerous exhibits in the Center focusing on the history of the Lake Superior Region, climate change, and the Refuge. A five-story observation tower allows visitors to look out across the Lake Superior shoreline.

The Center hosts numerous environmental education and interpretative programs each year as well as several special events. Refuge staff participates in programs and events that align with the Refuge’s mission. On average, 120,000 people visit the Center each year, providing an excellent forum for education about the Lake Superior region.

Administration

Whittlesey Creek National Wildlife Refuge is managed from the St. Croix Wetland Management District (WMD) in New Richmond, WI approximately 160 miles away. A Park Ranger (currently vacant) and an FWS biologist are stationed at the Refuge at an office in the NGLVC.

Management, maintenance, and administrative support are coordinated from the St. Croix WMD office.

Facilities

The Refuge office is located in the 32,000 square foot NGLVC, which has an exhibit area, auditorium, classrooms, and gathering areas (Figure 3-13). The Refuge has a screened-in facility for educational programming (Coaster Classroom), a small storage shed, and a pole barn for storage of equipment and supplies.

Law Enforcement

Law enforcement coverage for the Refuge is provided by the Zone Law Enforcement Officer located at Necedah National Wildlife Refuge, about 250 miles from the Refuge. Local issues needing immediate attention are handled through the Bayfield County Sheriff, local WDNR Wardens, and the U.S. Border Patrol.

Farm Services Agency Easements

When the Farm Services Agency (FSA, formerly known as the Farmers Home Administration) acquires property through default on loans, it is required to protect wetland and floodplain resources on the property prior to public resale. The Service assists the FSA in identifying these important resources. The FSA assigns a perpetual conservation easement to qualifying properties and transfers easement management responsibility to the Service as part of the Refuge System. The Refuge manages 15 FSA easements in a three-county management district. Easements are inspected each year. The Refuge and partner agencies have completed several wetland, in-channel, and riparian restoration projects on easements.

Figure 3-13: Visitor Services Facilities