HABITAT MANAGEMENT PLAN FOR SENEY NATIONAL WILDLIFE REFUGE (MICHIGAN, 2013)

Habitat Management Plan

for

Seney National Wildlife Refuge

APPROVALS		
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Synopsis

1. **Habitat management, by its very nature, is an art guided by science. This planning document attempts to justify current and future management actions based on our contemporary (and incomplete) understanding of the natural world and the realistic probability that work can be completed with current staffing and funding. We use geographically-relevant literature and other data to support statements and proposed management actions as best as possible. Much of the literature used is a product of the refuge's long history of functioning as a *de facto* Land Management and Research Demonstration Area.**
2. **Seney NWR is an *outlier* in the National Wildlife Refuge System (NWRS); unlike many refuges (Scott *et al.* 2004; Griffith *et al.* 2009) Seney is relatively large, exists in a matrix of public lands with a low human population density, and is surrounded by native land covers (Corace *et al.* 2012a).**
3. **Although two major ecological processes have been altered on the refuge (namely fire and hydrology) and some structural and compositional changes have occurred, Seney is perhaps the most ecologically "intact" refuge in the Midwest. The wildlife community too is primarily representative of those of the past, with intact predator-prey relationships existing.**
4. **Based on the above, the Seney NWR *Comprehensive Conservation Plan* (CCP, 2009) took a broad perspective on refuge management and outlined a land-ecosystem management gradient from east to west over the refuge's four management units. This gradient covers the conservation of the relatively altered Unit 1 Pool System, an emphasis on restoration of landscape patterns in Units 2 and 3, and the preservation of relatively intact habitats and landscape patterns in Unit 4, the Seney Wilderness Area. Many conditions in the latter are used to guide restoration in Units 2 and 3.**
5. **Habitat (land-ecosystem) management focuses on promoting the "natural range of variability" (NRV, Landres *et al.* 1999) of composition, structure, and disturbance within the context of the *Refuge Improvement Act* and the *Biological Integrity Policy* (Schroeder *et al.* 2004; Scott *et al.* 2004; Meretsky *et al.* 2006). NRV functions as the "trigger" for most actions, but these patterns needs to be quantified in many instances. Consequently, most approaches will be more "coarse" and "meso-filtered", rather than "fine-filtered" (Hunter 2005).**

6. **For much of the refuge's history, the anthropogenic pool system that comprises <5% of the total refuge area was a priority of management. Intensive management of these pools resulted in a number of successes (Johnson 1939; Fjetland 1973; Corace *et al.* 2006). Although still important, this HMP deemphasizes (but does not abandon) the management of anthropogenic habitats (e.g., pools, nest boxes/structures) and instead focuses on natural analogs (e.g., American beaver ponds, dead trees or snags). In doing so, the authors attempt to provide a better balance between the approaches of conservation biology and restoration ecology (Young 2000).**
7. **Habitat management will focus on retaining critical ecosystems and habitat types, maintaining refuge biodiversity, and maintaining or restoring (where possible) ecosystem patterns and processes (Holling and Meffe 1996) across the refuge's four management units and the associated seven ecological land units (Landtype Associations, LTAs, Cleland *et al.* 1997). Depending on approach, the potential for novel ecosystems exists (Hobbs *et al.* 2009).**
8. **Applied research and graduate student education are an integral part of adaptive management (McLain and Lee 1996) and fulfill to an imperfect degree some aspects of inventory and monitoring on the refuge. Applied research is generally focused on vegetation patterns and ecological processes, monitoring is focused on wildlife.**

Note: Many terms used in this document were defined in the Seney NWR CCP and readers can view that document for more definitions. The term "ecological integrity" is used with the definition being: "A natural community has ecological integrity if: 1) ecological processes are intact and within their natural range of variation; 2) species distribution, composition, and relative abundance are within their natural range of variation; 3) the community is resilient, or able to recover from severe disturbance events." The term "restoration" is used to describe the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. "Conservation" is defined as active management to maintain existing conditions, more or less. "Preservation" is defined as passive management that allows patterns to develop without intervention. "Benchmark" or "reference" refers to sites or conditions that have not been altered since pre-European times. "Natural range of variation" (NRV) means the range of values explaining patterns/processes expected in natural (unaltered) systems. See Appendix E for binomial names.

Acknowledgments: The authors appreciate the support of colleagues at Seney NWR and elsewhere in the National Wildlife Refuge System, including those who previously worked on the CCP from the Regional Office. Special thanks to Jane Austin (USGS), Charles Goebel (The Ohio State University), Tom Pypker (Michigan Technological University), Dan Kashian (Wayne State University), and Nancy Seefelt (Central Michigan University). We would also like to thank the Applied Sciences Program interns (including Cary Fado) and the numerous graduate students who assisted with data collection, analysis, and reporting.

I. Introduction

A. Scope and rationale. The following is a Habitat Management Plan (HMP) that describes the overall concepts, goals, objectives, and strategies for the management of ecosystems and associated habitats at Seney National Wildlife Refuge (hereafter Seney NWR or the refuge). **The only habitat management to be done at the Whitefish Point Unit is invasive plant management and this is covered in the *Integrated Pest Management Plan, see Appendix G*.** The HMP for Kirtland's Warbler Wildlife Management Area (the main satellite refuge with active land management) is a separate document. The other satellite refuges managed by Seney NWR (i.e., Huron NWR, Michigan Islands NWR, and Harbor Island NWR) are Great Lakes island refuges and do not have active habitat management programs.

B. Legal mandates. A number of *Acts* and policies direct this HMP. An overview of pertinent legal mandates can be found in the CCP (2009). For this HMP, the following are especially pertinent:

1) Seney NWR was established in 1935…*"... as a refuge and breeding ground for migratory birds and other wildlife..."* Executive Order 7246, dated Dec. 10, 1935.

2) This HMP also rests upon the legal mandate of the *National Wildlife Refuge System Improvement Act* of 1997, 16 U.S.C. 668dd and the *Biological Integrity, Diversity, and Environmental Health Policy* of 2001, 601 FW3. Considered the "Organic Act of the National Wildlife Refuge System," the *Improvement Act* defines the mission of the System, designates priority wildlife-dependent public uses, and calls for comprehensive refuge planning. The *Biological Integrity, Diversity, and Environmental Health Policy* is an additional directive for refuge managers to follow while achieving refuge purpose(s) and the System mission. It provides for the consideration and protection of the broad spectrum of fish, wildlife, and habitat resources found on refuges and associated ecosystems. Further, it provides refuge managers with an evaluation process to analyze their refuge and recommend the best management direction to prevent further degradation of environmental conditions; and where appropriate and in concert with refuge purposes and System mission, restore lost or severely degraded components.

Mission statements — The mission of the U. S. Fish and Wildlife Service (Service) is: *"Working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefits of the American people."*

The mission of the National Wildlife Refuge System is: *"To administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans."*

The mission of Seney NWR, as described in the approved CCP (2009), is as follows:

"Seney National Wildlife Refuge will continue to be a place of excitement and wonder where wildlife comes first. It will be a place where management decisions are made in the best interest of wildlife and their habitats, and people are encouraged to explore and learn about the natural world. The Refuge's rich mosaic of habitats and ecosystems will be viewed as part of the greater eastern Upper Peninsula of Michigan ecoregion. Priority will be given to managing for those species, habitats, and ecosystems of regional concern that are best suited to Seney's unique environment. Management will maintain Refuge-level biological diversity while preserving ecological integrity. Habitats will be managed for an array of ecological conditions, including the preservation of Wilderness character. When and where appropriate, an emphasis will be placed on preserving or restoring historic habitat conditions and ecosystem functions. As part of a holistic approach to natural resource stewardship, people will be welcomed to use the Refuge to learn about the natural world. The public will be invited to participate in wildlife-dependent experiences that are in concert with the relatively undeveloped nature of the Refuge. Students and researchers will be encouraged to use the Refuge as an outdoor laboratory for biological and ecological research that focuses on understanding natural patterns and processes and developing habitat management techniques. Seney NWR will continue to be a source of pride for the staff, those who visit, and the local community. It will showcase biological and ecological diversity, habitat management, and wildlife-dependent public use. It will add to the richness of the broader community by holding in trust a portion of the natural heritage of the eastern Upper Peninsula of Michigan for the continuing benefit of the American people."

C. Relationship to other plans. This HMP is a step-down plan to the CCP and is related to the *Seney NWR Fire Management Plan* (2005). As much as is possible, this HMP takes information directly from the CCP and provides more detailed and site-specific information. In a few instances (e.g., objectives/strategies for fish surveys), this HMP does make minor changes to areas of the CCP. These changes are due to new information from research and staffing limitations. This HMP also takes into account the *Seney Biological Program Review* (2006), the *Michigan Wildlife Action Plan* (2005), the *Michigan Important Bird Area* assessment (2011), and related USFWS documents (e.g., *Upper Mississippi Valley/Great Lakes Waterbird Conservation Plan*).

II. Background.

Seney NWR was established in 1935 by Executive Order under the *Migratory Bird Conservation Act* for the protection and production of migratory birds and other wildlife. The refuge encompasses approximately 95,238 acres; 25,150 acres comprise the Seney Wilderness Area in which is embedded the Strangmoor Bog National Natural Landmark (approximately 9,600 acres). When combined with other Natural Areas, approximately 26% of Seney NWR is set aside from most manipulative activities. According to 2011 inventory data, 20 species of reptiles and amphibians, 48 species of mammals, 26 species of fish, 200+ species of birds, and 400+ plant species have been documented on the refuge. The land management paradigm associated with Seney and the surrounding area has shifted over time from exploitation (Verme 1996; Losey 2003), to utilitarianism and game management (Johnson 1939), to landscape and disturbance ecology within an ecosystem restoration context (Kowalski and Wilcox 2003; Corace *et al.* 2009; Bork *et al.* 2013).

A. Inventory and description of habitat.

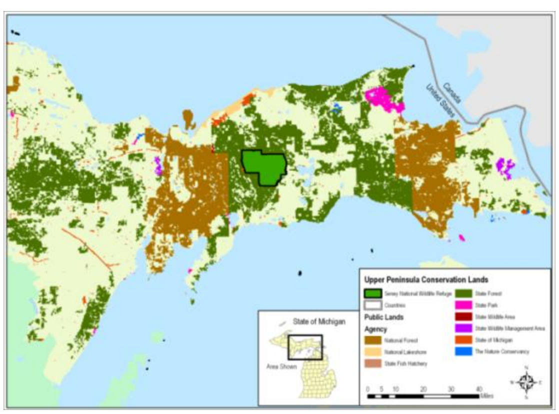


Figure 1. Land ownership patterns, eastern Upper Peninsula of Michigan.

(1) Location — Seney NWR is located in Schoolcraft County in Michigan's eastern Upper Peninsula (hereafter, eastern UP). Human density is low, approximately 8 people/mi^2, making the area one of the lesser populated regions of the Midwest. The closest towns with populations >2,000 are Manistique, Munising, and Newberry; all three are 40 miles away from the Refuge.

Approximately 80% of the ecoregion in which Seney NWR is found consists of public lands (Corace *et al.* 2012a), and a majority of the private lands are owned and managed by timber corporations or related large ownership types (Figure 1, above).

(2) Management units —Seney NWR is comprised of four Units, with Unit 4 being the Seney Wilderness Area (Figure 2).

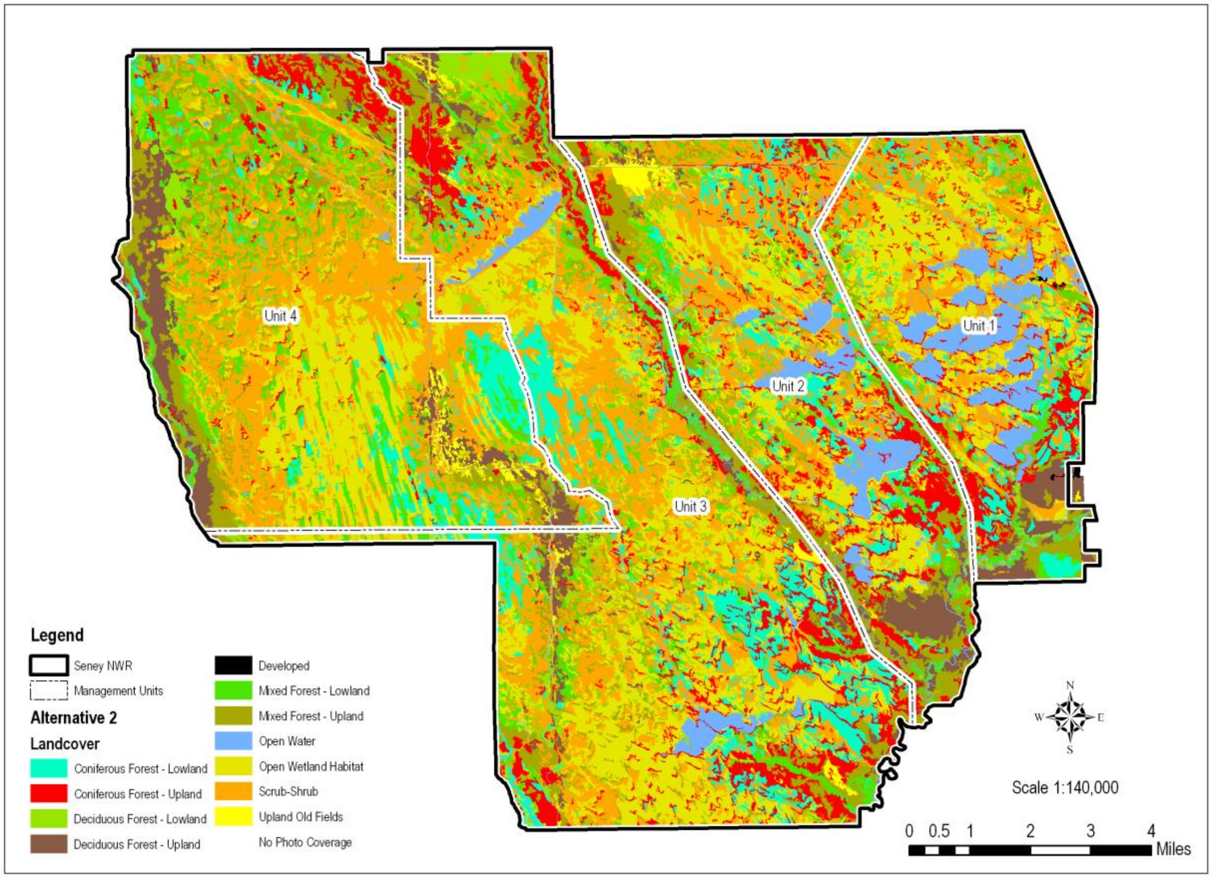


Figure 2. Management Units of Seney NWR and associated landcover per the preferred alternative of the CCP. A gradient of land management philosophy exists: from a landscape pattern conservation emphasis in Unit 1, to a landscape pattern restoration emphasis in Units 2 and 3, to a landscape pattern preservation emphasis in Unit 4 (Seney Wilderness Area). Altered conditions in Unit 1, especially, may characterize novel ecosystems (Hobbs *et al.* 2009).

(3) Physical or geographic setting

a. Climate — The climate of Seney NWR is influenced by its proximity to Lake Superior and Lake Michigan. Spring through early fall winds are commonly from the southwest to northwest. Average daily humidity during spring and fall varies from 50 to 60%. Yearly temperature extremes range from approximately -35 degrees Fahrenheit to 98 degrees Fahrenheit. Precipitation occurs throughout the year, with June being the wettest month and March the driest (on average). Average annual precipitation is 32 inches, and average annual snowfall is 123 inches. Average growing season evaporation is 25 inches, and the average length of the growing season is 119 days.

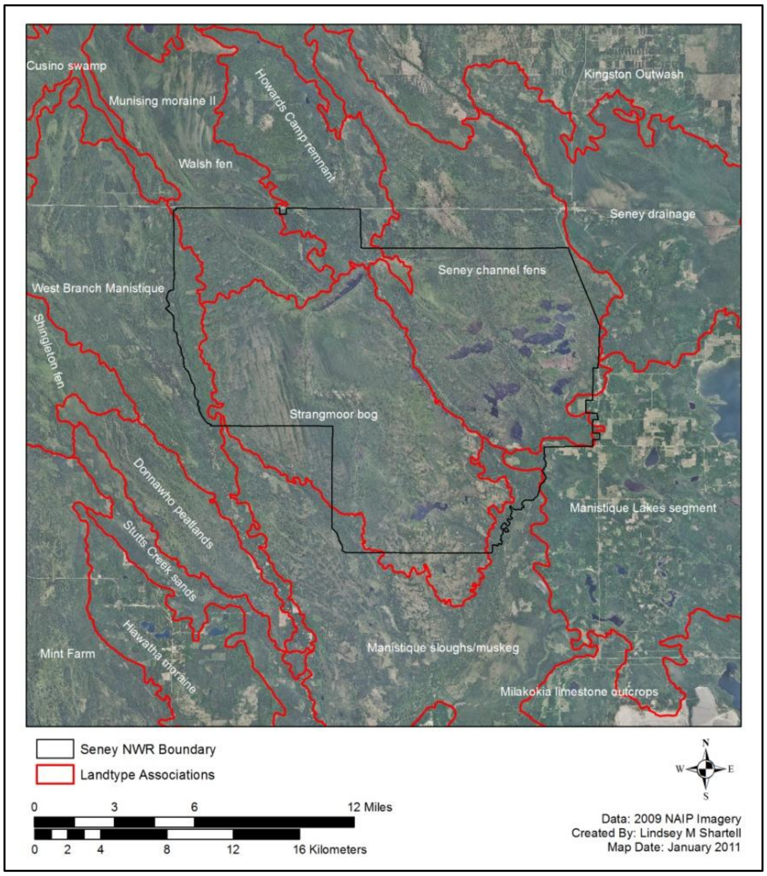


Figure 3. Landtype Associations of Seney NWR.

b. Landscape ecosystems and glaciation — According to the hierarchical landscape classification system of Albert (1995), Seney NWR represents 11% of the Seney Sand Lake Plain ecoregion (Sub-Subsection VIII.2.1). This Sub-Subsection is characterized by landforms of lacustrine origin with broad, poorly drained embayments containing beach ridges, swales, dunes, and sandbars. Embedded within the Seney Sand Lake Plain are a number of Landtype Associations (LTAs), seven of which are found on the refuge (Cleland *et al.* 1997, Figure 3).

Although relatively little topographic relief exists on the refuge, the broad, flat lands reflect a subtle, but highly complex, geologic history. Between 10,000 and 10,500 years ago, the "Valders" pro-glacial lakes in the Superior basin drained southward. At about the latter date, the Valders ice border was located along the southern shore of Lake Superior allowing meltwater to drain southward across what is now the refuge. During this period of time, the present land surface appears to have been sculptured. At least two phases of drainage seem to be visible in the surface patterns of the area. The first of these is a broad channel eroded into earlier outwash deposits that carried meltwaters from the area of Long Lake southward through what is now termed the Strangmoor Bog (Heinselman 1965). Throughout the length of this channel now occur linear landforms composed of sandy sediments; these formations may have been formed when forest cover declined and vast amounts of sand were exposed to the effects of wind (Loope *et al.* 2012). A second generation of outwash channels is visible as linear peat-filled depressions trending northwest to southeast across the refuge. These landforms are now considered unique patterned bog topography and are prominently visible near Creighton and in the refuge lands west of the Driggs River (Seney Wilderness Area).

c. Soils — Within the Seney Sand Lake Plain, 100 to 200 feet of glacial drift generally cover the bedrock. The soils on the refuge are largely level to somewhat sloping mucks, peats, and sands. The natural drainage is very poor in the mucks and excessive in the sands on ridges and knolls. This complex covers the majority of the refuge. A large area of Dawson and Greenwood peats exists in the central portion of the refuge. These level, very poorly drained soils are composed of brown or yellow-brown mixed fibrous and woody material. At depths of 1 to 2 feet, raw yellow peat or muck underlies the peat. Very little decomposition has taken place in the areas of yellow peat. The water table is at the surface most of the year. Areas of Carbondale and Tawas mucks interrupt the peats on the refuge. Wet sands underlie the entire area. Along the Manistique River Valley, Driggs River, and the other tributaries, the soils are predominately sands and sandy loams. These soils are well or excessively drained and lie on slopes that are level to steeply sloping. The soil surface consists of forest litter, underlain by gray sandy loam or fine sandy loam, with coarser sand beneath the loam. According to the habitat typing system of Burger and Kotar (2003), a total of 31 soil types (61%) at the refuge have either primary or secondary habitat types (documented successional trajectories). All are upland soils. Of these, 18 (58%) have eastern white pine as a climax species and 13 (42%) have maple (sugar or red) as climax species (Table 1, below; Appendix B). This system does not at present provide primary or secondary successional pathways for wetland soils.

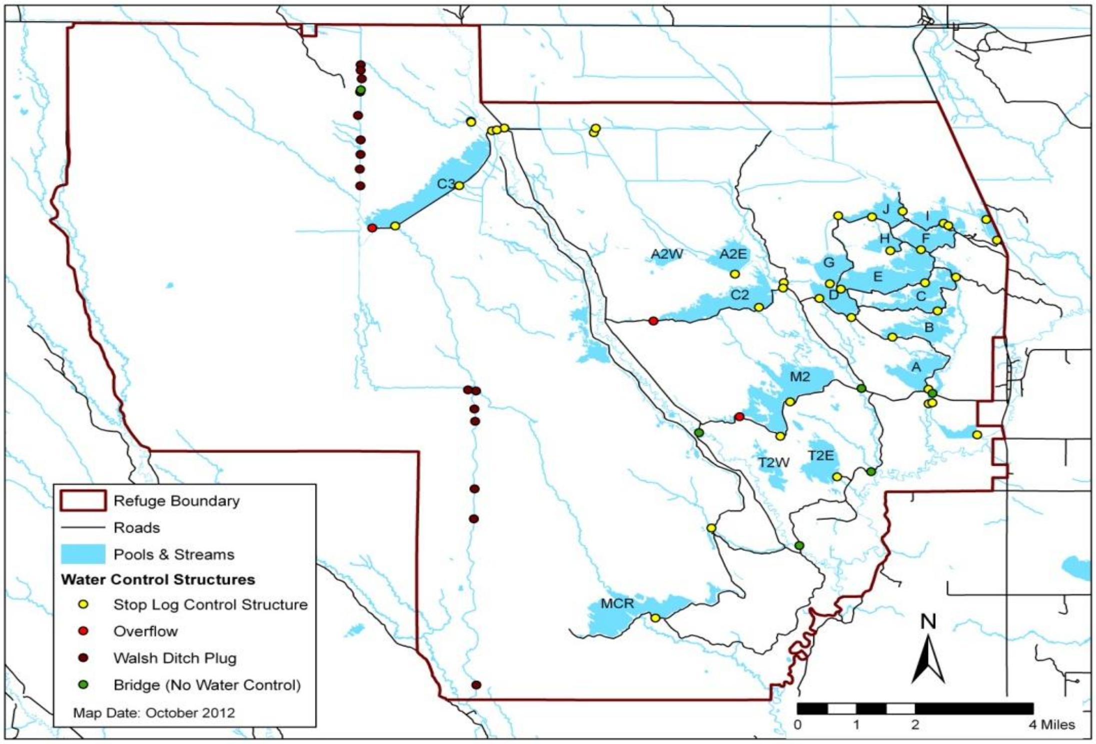
d. Surface Hydrology — Seney NWR lies within the Manistique River watershed. The watershed drains approximately 1,465 mi^2 before emptying into the northeast corner of Lake Michigan (Madison and Lockwood 2004). Seney NWR includes 27 anthropogenic pools, with water control capability on 21 (Figure 4, below). General land slopes are approximately 10 ft/mi and southeasterly in direction. Water enters the refuge from the north and northwest through the following creeks, from west to east: Marsh Creek, Ducey Creek, Walsh Creek, Driggs River, Holland Ditch, and Clarks Ditch. Water then flows south-southeast to the Manistique River (Figure 5, below). The Manistique River then flows into Lake Michigan. Precipitation accounts for approximately 60% of the refuge water intake. The remaining 40% of the water supply comes from the ditches, rivers, and creeks.

Table 1. Ranked order of soils[a] at Seney NWR base on acreage. Only soils covering >1% of the total area are listed (~30 soil types that cover ~3,904 acres not listed). Diagrams showing successional trajectories on upland soils can be found in Appendix B.

Soil Name	Approximate Acreage	Percent (%) of Refuge	Primary/Secondary Habitat Types
Markey Mucky Peat	43,750.54	46	None/None
Deford-AuGres-Rubicon Complex, Deep Water Table, 0-15% Slopes	7,392.33	8	None/PArV
Water	5,977.39	6	-
Loxley-Carbondale Complex	5,907.52	6	None/None
Neconish-Kinross-Wainola Complex, 0-6% Slopes	3,549.25	4	PVE/None
Deford Muck	3,326.52	3	None/None
Dawson-Greenwood-Loxley Peats	3,279.17	3	None/None
Markey-Deford Mucks, Drained	1,951.01	2	None/None
Rousseau-Neconish-Spot Complex, 0-25% Slopes	1,881.52	2	PVE/None
Histosols and Aquents, Ponded	1,638.54	2	None/None
Kinross-AuGres-Rubicon Complex, Deep Water Table, 0-15% Slopes	1,500.92	2	None/PArV
Carbondale-Lupton-Tawas Mucks	1,451.84	2	None/None
Deford-AuSable-Tawas Mucks	1,315.76	1	None/None
Pelkie (Occassionally Flooded)-Deford (Frequently Flooded) Complex, 0-6% Slopes	1,302.31	1	None/None
Proper Fine Sand, 0-6% Slopes	1,265.60	1	PVE/None
Rousseau-Proper-Deford Complex, 0-25% Slopes	1,189.31	1	PVE/None
Meehan-Deford-Seney Complex, 0-3% Slopes	1,056.91	1	PArVAa/None
Finch-Spot Complex, 0-3% Slopes	887.93	1	PArVAa/None
Duck-Rubicon, 0-15% Slopes	826.92	1	PArVAa/PArV
Clemons-Deford Complex, Very Rarely Flooded, 0-15% Slopes	738.32	1	None/None
Rousseau Fine Sand, 15-35% Slopes	599.66	1	PVE/PArV
Markey-Deford Mucks, Drained	547.65	1	None/None
Total	**91,334**	**96**	**-**

Sheet flow (overland flow) is quite substantial each spring as a result of winter snow and ice stores melting. Ground water is discharged into the peat and streams and flows under streambeds as hyporheic flow. Peak flows through marsh and water systems normally occur during spring. Snowmelt, frozen ground, and rain can combine to create floods that may threaten anthropogenic pool dikes, although such events are rare. Overall the discharges are relatively low due to the large amount of wetland and depression storage located in the watershed

Figure 4. Surficial hydrology and related pools, water control structures, ditches, ditch plugs, etc. at Seney NWR.



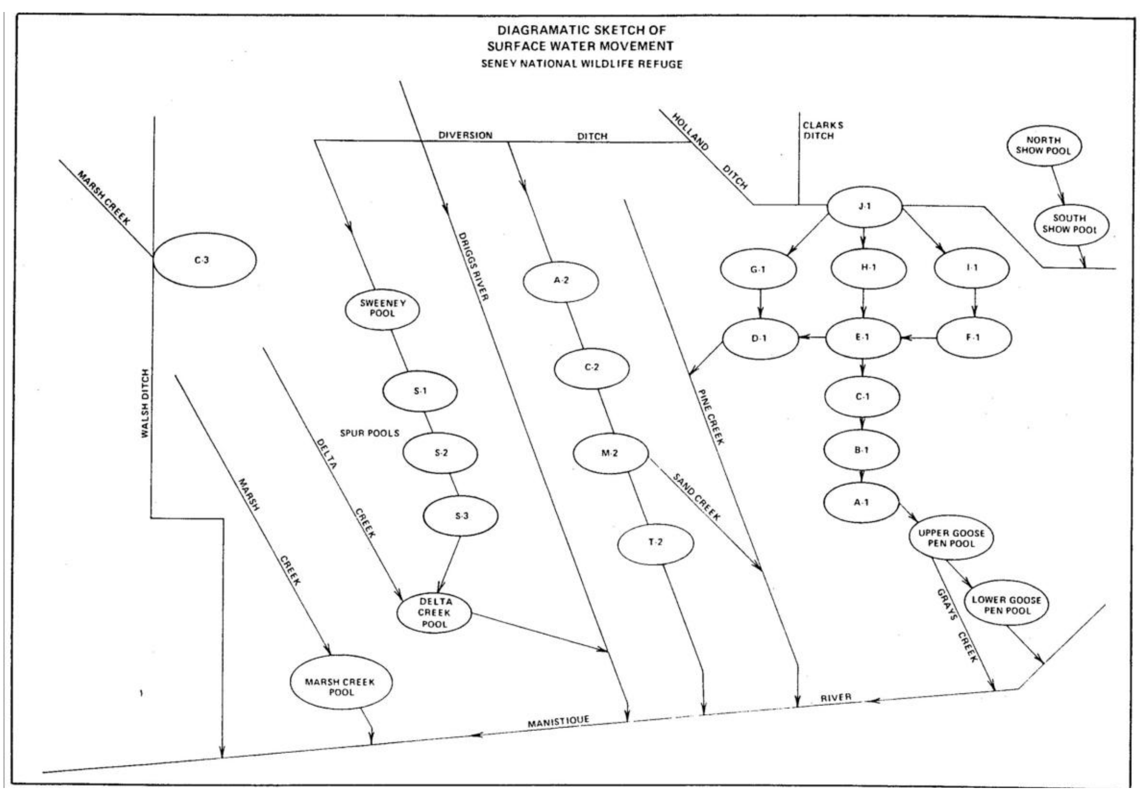


Figure 5. Planned (and originally desired) water flow via natural and anthropogenic waterways at Seney NWR. The actual movement of water is now not as clear due to landscape changes and should be quantified.

(4) Historic condition — Zhang *et al.* (2000) claim that plant composition in the Seney area is primarily the consequence of species migration in response to climate change after the retreat of the Wisconsin glaciation and human intervention during the last two centuries. General Land Office (GLO) notes depict the Seney area prior to European settlement as consisting of a mosaic of upland and wetland cover types (Table 2, Comer *et al.* 1995). Research has suggested that Native American use of the landscape prior to European settlement was minimal, at best (Silbernagel *et al.* 1997). Therefore, it is unlikely that any direct and significant human alteration of the landscape occurred before European settlement.

Table 2. Pre-European cover types of Seney NWR by area[a] and percent of total.

Cover Type	Acres	Percent (%) of Refuge
Muskeg-Bog	64,678	68
Mixed Conifer Swamp	11,699	12
White Pine-Red Pine	5,354	6
Jack Pine-Red Pine	4,462	5
Hemlock-White Pine	2,479	3
Beech-Sugar Maple-Hemlock	1,785	2
Spruce Fir-Cedar	1,719	2
Hemlock-Yellow Birch	859	1
Shrub Swamp-Emergent Marsh	661	1
Aspen-Birch	595	1
Lake or River	264	<1
Mixed Hardwood Swamp	165	<1
Black Ash	132	<1
Cedar Swamp	66	<1
Sugar Maple-Hemlock	33	<1
Total	**94,851**	**100**

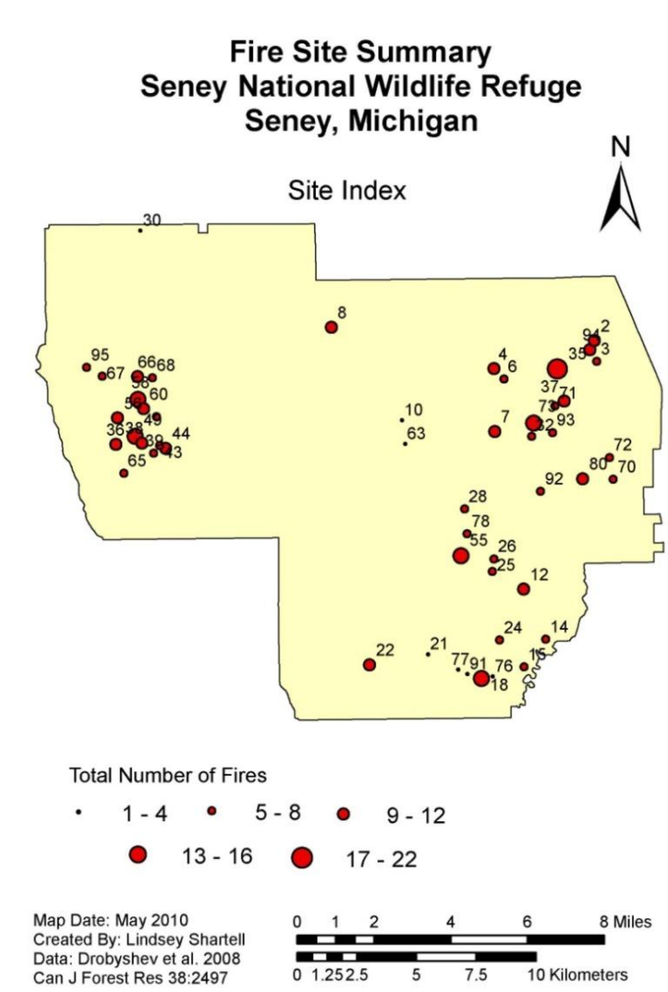
[a]Above information from Comer *et al.* (1995). The older refuge digital boundary used did not correspond exactly to present-day ownership of 95,238 acres, but no change in patterns should be expected.

(5) Changes from historic condition — A crude comparison of historic changes in land cover across LTAs is provided in Appendix C. In general, changes in the landscape relative to the pre-European condition were brought about by three main human activities: late 19th to early 20th century logging of primarily mixed-pine forests, followed by ditching for (failed) agricultural attempts in the early 1900s, and creation of anthropogenic pools since refuge establishment (Losey 2003). These activities have altered two main ecological processes, fire (Drobyshev *et al.* 2008a,b) and hydrology (Kowalski and Wilcox 2003; Welsh 2011; Bork *et al.* 2013). Although both wetlands and uplands have been impacted, Seney's present-day land cover patterns indicate a relatively high-degree of ecological integrity relative to many other Midwest refuges (Corace *et al.* 2012a). This is due, in part, to surrounding land use practices (primarily forest management) and low population density/human development.

a. Changes due to exploitation and altered fire and hydrologic regimes — Before its establishment, the forests and soils of the Seney Sand Lake Plain were exploited to a considerable degree, starting in the late 1800s (Karamanski 1989; Comer *et al.* 1995; Verme 1996; Losey 2003). Early timber cutting favored the best stands of eastern white pine, followed by "high-grading" in the red pine and hardwood-eastern hemlock stands. Slash fires fueled by logging debris occurred outside the natural range of variation, with many areas burning time and time again (Drobyshev *et al.* 2008a). On many areas of the refuge, the scars from these lumbering operations remain visible to this day (Drobyshev *et al.* 2008b; Corace *et al.* 2009; Corace *et al. In Press*). By 1912, drainage of the Seney Swamp was underway. A land development company dug many miles of drainage ditches throughout the area (Kowalski and Wilcox 2003; Welsh 2011; Bork *et al.* 2013). The drained acreage was then sold using extravagant promises of agricultural productivity. The new owners quickly learned that these promises were unfounded. The farms were abandoned, and the exploited lands reverted to state ownership, and then to the federal government.

Physical development of the refuge began soon after its establishment (Losey 2003). With the aid of the Civilian Conservation Corps, an intricate system of dikes, water control structures, ditches, and roads was built. Most of these are still in use today. Thus, one of the major differences between the Seney NWR landscape of the present-day and that of the pre-European period is the present abundance of standing (pooled) water. Altered hydrology has had some benefits in providing waterbird habitat, but has also degraded nearby wetlands and promoted conditions for invasive plants and other altered processes (e.g., reduced carbon sequestration by reducing peat formation, tree growth in wetlands, altered fire regimes by disconnecting fuels).

In the eastern UP, mixed-pine forests comprised approximately 38% of the pre-European ecoregional landscape (Zhang *et al.* 2000). The distribution of these forests, and other ecosystems, across the landscape was regulated primarily by the interaction of topography, soil moisture, and fire frequency. Studies have documented the natural range of variation (NRV) of these mixed-pine forests and the disturbance regimes associated with them over the past 300+ years and these function as "triggers" or "desired future conditions" in many instances. For instance, prior to European settlement data suggest that fire occurred at least once every 50-60 years, with six large (landscape-scale) events occurring over 300+ years at a mean interval of approximately 37 years (removing the “Great Cutover” period of 1910, range: 27-73 years) (Figure 6). These landscape-scale fire events occurred in the following years: 1754, 1791, 1864, 1891, 1910, 1976 (Drobyshev *et al.* 2008a). However, smaller fires likely occurred more frequently. Nonetheless, since refuge establishment the fire return interval has differed from the pre-European pattern. In many areas, it has been increased, while in some sites decreased. These changes are likely the result of less burnable vegetation on the refuge (due to more water being impounded in the pool system) and some management activities that pushed vegetation and disturbance patterns outside the NRV of the landscape. Fire rotation has been increased 10-fold.



FireSiteID	Years with Fire								
2	1823	1864	1870	1877	1882	1897	1915	1925	1936
	1942								
3	1707	1763	1791	1882	1891	1936			
4	1684	1707	1754	1791	1826	1833	1848	1864	1871
	1919	1925							
6	1871	1882	1888	1889	1895	1907	1919	1925	
7	1717	1754	1791	1832	1864	1871	1881	1895	1919
	1963								
8	1791	1832	1836	1841	1846	1858	1873	1919	1976
	1994								
10	1891	1906	1919	1931					
12	1680	1721	1743	1754	1791	1821	1843	1854	1858
	1864	1891	1919						
14	1754	1791	1834	1854	1864	1871	1882	1919	
15	1614	1640	1717	1754	1776	1791	1864	1919	
18	1694	1721	1754	1783	1797	1803	1871	1880	1883
	1888	1903	1919	1951	1954	1972			
21	1864	1895	1919						
22	1791	1864	1891	1895	1906	1919	1976	1992	2004
24	1803	1827	1864	1919	1970	1976			
25	1754	1824	1827	1864	1891	1919	1976		
26	1754	1791	1810	1827	1848	1863	1922	1952	
28	1791	1832	1863	1868	1882	1910	1922		
30	1919	1976							
32	1864	1867	1886	1891	1895	1903	1919		
35	1697	1717	1754	1758	1777	1791	1841	1864	1867
	1870	1877	1887	1898	1914	1925	1936		
36	1731	1754	1791	1864	1891	1910	1919	1925	1934
	1936	1976							
37	1802	1827	1867	1912	1919	1925	1936	1988	2003
38	1791	1864	1891	1910	1925	1938	1953	1976	1987
39	1738	1791	1864	1875	1910	1919	1925	1976	
43	1791	1864	1867	1891	1910	1976			
44	1690	1729	1791	1858	1910	1919	1946	1958	1976
45	1791	1823	1864	1867	1891	1910	1919	1976	
49	1712	1754	1774	1791	1797	1864	1867	1882	1891
	1910	1919	1936	1943	1946	1976			
55	1754	1776	1791	1827	1857	1864	1868	1876	1881
	1891	1919	1956	1976					
56	1768	1791	1864	1910	1919	1925	1936	1943	1976
58	1596	1634	1668	1719	1791	1820	1838	1846	1864
	1867	1878	1881	1891	1895	1910	1919		
60	1754	1762	1791	1843	1864	1867	1891	1910	1919
	1976								
63	1891	1906	1919						
65	1791	1845	1864	1891	1919	1953	1976		
66	1693	1748	1791	1864	1886	1891	1910	1919	1923
67	1767	1791	1827	1841	1883	1886	1976		
68	1719	1769	1791	1864	1896	1919	1923	1976	
70	1870	1892	1900	1908	1919	1933			
71	1864	1882	1891	1906	1912	1936			
72	1776	1824	1864	1871	1891	1919			
73	1739	1754	1760	1776	1779	1791	1800	1815	1864
	1882	1891	1919	1925					
76	1864	1880	1976						
77	1891	1976							
78	1908	1919	1925	1931	1976				
80	1754	1791	1864	1871	1885	1891	1903	1912	1918
91	1891	1913	1919	1976					
92	1809	1864	1871	1882	1891	1907	1919	1931	
93	1754	1776	1791	1864	1882	1891	1903	1913	
94	1864	1872	1882	1893	1911	1914	1919	1925	1926
	1942	1988							
95	1791	1864	1886	1919	1929	1976			

Figure 6. Fire history data for Seney NWR (Drobyshev *et al.* 2008a). Circles denote locations where dendrochronological sampling occurred. Larger circles denote sites experiencing more fire over 300+ years. Table denotes the specific year(s) in which fire(s) was/were recorded for a given site.

(6) Current habitat types — Based on 2001 National Land Cover Data, Corace *et al.* (2012a) found Seney NWR and the Seney Lake Plain similar in many ways, with the Seney Sand Lake Plain being 67% forested and Seney NWR slightly less so due to anthropogenic pools. Increases in dominance of tree species have occurred primarily among shade-tolerant, fire-sensitive taxa (e.g., sugar and red maple, American basswood, balsam fir), and decreased among species that are shade-intolerant or mid-tolerant and dependent on fire (e.g., aspens, red and eastern white pines). Woody wetlands are an important component of Seney NWR and occur as the largest, most common, and least aggregated patch type on the refuge. Ultimately, the change in composition in this ecoregion is less than found in other ecoregions with refuges in the Upper Midwest. However, generally small patch sizes of forests in both the ecoregion and the refuge may still limit bird populations (Crozier and Niemi 2003; Corace *et al. In Review*). Just having forests does not mean you provide everything for forest-dependent species. For the purpose of the CCP and this HMP, the 41 vegetative cover types identified in the U. S. Geological Survey data layer (not including developed land) derived from interpreted 2004 aerial photos were combined into 10 habitat types (Table 3).

Table 3. Ranked order (by area and percent total area) of 10 habitat types at Seney NWR. Habitat types with active management emphasized during this 15-year planning period are denoted by *. See Appendix F for the lumping that was done among the 41 land covers in the base data layer to yield the table below.

Habitat Type	Acres	Percent (%) of Refuge
Scrub-Shrub*	28,954	30
Open Wetlands*	16,617	18
Mixed Forest-Uplands*	11,396	12
Coniferous Forest-Uplands*	8,857	9
Mixed Forest-Lowlands	8,221	9
Coniferous Forest-Lowlands	7,825	8
Open Water*	5,103	5
Deciduous Forest-Uplands*	4,372	5
Deciduous Forest-Lowlands	2,515	3
Upland Old Fields and Openland*	1,302	1
Total	**95,162**	**100**

III. Resources of Concern

A. Identification of refuge resources of concern. The CCP listed species, communities, and ecosystems as *Resources of Concern*. A total of 78 wildlife species (60 birds, 10 mammals, 4 fish, and 4 herptofauna) that were listed as either R3 *Conservation Priority Species*, USFS *Sensitive Species*, and/or had *Michigan Special Animal* status (MDNR) were included (Appendix D). The general process for inclusion was simple: if a species HAD BEEN found on the refuge, nearby lands, or satellite refuges and was found on one of the above lists it was included; this process produced a ponderous list. For the purposes of this HMP, the CCP list was reduced to a more manageable size by different means, with the resulting *Resources of Concern* list consisting of species that breed at the refuge, are impacted directly by land management, and for which the refuge is particularly important within the NWRS, R3, Michigan, or the eastern UP ecoregion.

Our reduction of the CCP started by getting rid of species that are very rarely encountered and do not breed here. For bird species, for instance, this meant that species such as Black Scoter, Golden Eagle, Peregrine Falcon, etc. were removed from the original list. Next, common gamebird species whose populations seemed to be doing relatively well (e.g., Canada Goose, Mallard, Wood Duck) were removed. Then bird species for which habitat management at Seney NWR *per se* was not a conservation issue (e.g., colonial waterbirds, such as Caspian Tern, found on satellite refuges) were removed.

We then used a 2010-2011 *Important Bird Area (IBA)* assessment for Michigan to select those bird species for which Seney NWR was a *Michigan IBA.* These species retain *Resources of Concern* status in this HMP: **Common Loon, Trumpeter Swan, Merlin, Northern Harrier, Osprey, Spruce Grouse, Sharp-tailed Grouse, American Bittern, Yellow Rail, Olive-sided Flycatcher, Le Conte's Sparrow (and Common Tern at a USCG facility located in St. Ignace and Piping Plover at Whitefish Point Unit)**. Finally, we retained a handful of species that data (Michigan Natural Features Inventory, MNFI, other) suggest Seney may be of special value in Michigan and the Midwest, the majority of which are R3 *Conservation Priority Species*, and all of which were listed in the CCP: **Whip-poor-will, Black-backed Woodpecker, and Sedge Wren.**

For mammals, herptofauna, and fish, further literature review was done to reduce the CCP list. Although species of interest such as gray wolf, fisher, marten, brook trout, etc. are found on the refuge and were listed in the CCP, there are no data that suggests that Seney NWR is critical for their persistence in Michigan. Moreover, it is unlikely any habitat management described herein would directly impact these species. Consequently, our updated HMP *Resource of Concern* list does not include any mammal or fish. We did maintain two species of herptofauna (mink frog, wood turtle) on the HMP list because they may be good indicators of water abundance and quality (Table 4).

Table 4. Updated list of *Resources of Concern* at Seney NWR by level of biological organization, main associated habitat type(s) and ecological process(es). Not listed are species found on other lands managed by Seney NWR: Kirtland's Warbler, Common Tern, and Piping Plover.

Resource of Concern	Biological Level	Associated Habitat Type(s)	Ecological Process(es) of Note
Common Loon*	Species-Population	Open Water (Pools)	Hydrology (Altered)
Trumpeter Swan*	Species-Population	Open Water (Pools)	Hydrology (Altered)
Osprey*	Species-Population	Open Water (Pools)	Hydrology (Altered)
Merlin	Species-Population	Numerous	?
Northern Harrier	Species-Population	Open Wetlands-Upland Old Fields	Hydrology, Fire
American Bittern	Species-Population	Open Wetlands	Hydrology, Fire
Yellow Rail	Species-Population	Open Wetlands	Hydrology, Fire
Le Conte's Sparrow	Species-Population	Open Wetlands	Hydrology, Fire
Sedge Wren	Species-Population	Open Wetlands	Hydrology, Fire
Sharp-tailed Grouse*?	Species-Population	Open Wetland-Upland Old Fields	Hydrology, Fire
Black-backed Woodpecker	Species-Population	Coniferous Forests-Uplands, Lowlands	Fire, Insect Herbivory
Spruce Grouse	Species-Population	Coniferous Forests-Uplands, Lowlands	Fire, Insect Herbivory
Olive-sided Flycatcher	Species-Population	Coniferous Forests-Uplands, Lowlands	?
Whip-poor-will	Species-Population	Coniferous Forests-Uplands, Shrub-Scrub	Fire, Insect Herbivory
Wood Turtle	Species-Population	Open Water (Rivers)	Hydrology
Mink Frog*?	Species-Population	Open Water-Open Wetlands	Hydrology
Seney Wilderness Area	Community-Ecosystem	Scrub-Shrub, Open Wetlands, Coniferous Forests-Uplands, Lowlands	Fire, Hydrology
Strangmoor Bog National Natural Landmark	Community-Ecosystem	Scrub-Shrub, Open Wetlands, Coniferous Forests-Uplands, Lowlands	Fire, Hydrology
Strangmoor Bog RNA	Community-Ecosystem	Scrub-Shrub, Open Wetlands	Fire, Hydrology
Red Pine RNA	Community-Ecosystem	Coniferous Forests-Uplands	Fire, Insect Herbivory
Hemlock RNA	Community-Ecosystem	Coniferous Forests-Lowlands	Hydrology, Insect Herbivory
Sugar Maple-Beech-Yellow Birch RNA	Community-Ecosystem	Deciduous Forests-Uplands	Wind
White Pine PUNA	Community-Ecosystem	Coniferous Forests-Uplands	Wind, Fire
Northern Hardwoods PUNA	Community-Ecosystem	Deciduous Forests-Uplands	Wind

*Primarily dependent on anthropogenic habitat(s).

If a "Surrogate Species" approach were taken American beaver (a landscape engineer), white-tailed deer (also, when in high abundance, a regulator of ecosystems), and gray wolf (a predator of white-tailed deer and American beaver), the Black-backed Woodpecker (indicator of fire in conifer forests), and the American Bittern (indicator of wetland quality) would be proposed. However, because: 1) Seney NWR lacks any known breeding populations of any Federal T/E wildlife species (other than Piping Plover at the Whitefish Point Unit, monitoring of which is handled by Ecological Services, and Kirtland's Warbler at Kirtland's Warbler WMA, monitoring of which is done by a multi-agency effort, see *Inventory and Monitoring Plan*) and 2) has existing landscape patterns conducive to the management of more broad-scale patterns and processes within the context of the 1997 *Improvement Act* and the *Biological Integrity, Diversity, and Environmental Health Polic*y (2001) it was deemed that many of the *Resources of Concern* for this HMP should be Natural Areas and ecological patterns and processes within the habitat types mentioned above and across the land management gradient (conservation-restoration-preservation).

Natural Areas — A number of set-aside areas exist at Seney NWR and the *quantified* structure and function of these areas provide the underpinning for habitat conservation and restoration: the Seney Wilderness Area (25,150 acres) and the embedded the Strangmoor Bog National Natural Landmark (9,600 acres) and its G-32 Strangmoor Bog Research Natural Area (RNA, 640 acres); the Society of American Foresters (SAF) 15 Red Pine RNA (100 acres); the SAF 23 Hemlock RNA (50 acres), the SAF 25 Sugar Maple-Beech-Yellow Birch RNA (350 acres); the White Pine Public Use Natural Area (PUNA, 30 acres), and the Northern Hardwoods PUNA (68 acres) (Figure 7). Many conditions in Natural Areas provide restoration benchmarks. **However, patterns associated with the NRV of wetlands (in particular) need to be quantified to provide management "triggers" and quantified**

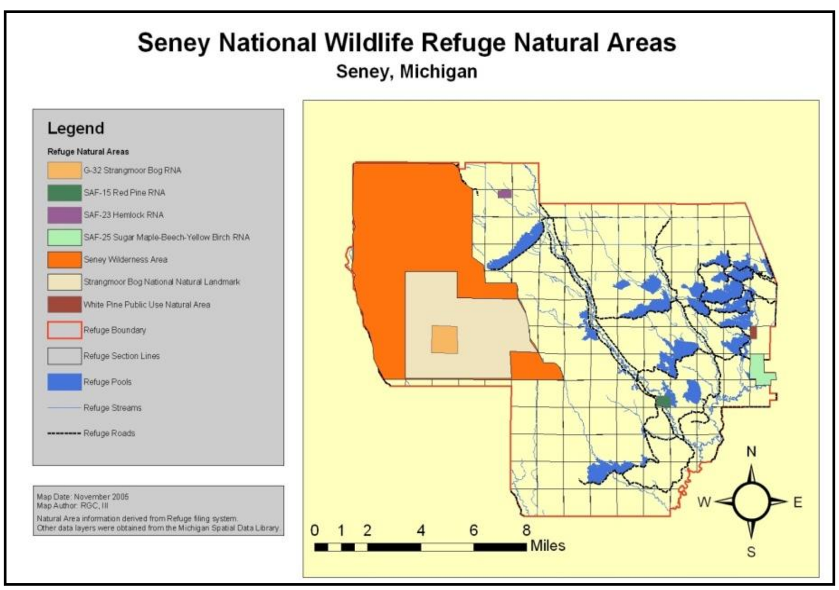


Figure 7. Natural Areas of Seney NWR.

objectives. Studies should be undertaken to compare reference or benchmark wetland patterns in the Seney Wilderness with altered patterns in Units 1-3.

B. Management of refuge resources of concern.

(1) Management of non-Wilderness Natural Areas — In a 1966 memorandum from the Acting Director (Bureau of Sport Fisheries and Wildlife) two types of RNA management scenarios were described. In one, succession is allowed to advance towards climax without interference (e.g., SAF 25 Sugar Maple-Beech-Yellow Birch RNA). In the other, appropriate management is applied to hold succession at a desired natural stage that would otherwise advance towards something different (e.g., SAF 15 Red Pine RNA). However, no documents were found indicating how these two scenarios are to be applied to RNAs at the refuge. Moreover, based on the fact that two different types of Natural Areas have been established at the refuge with Regional Office (and higher) approval, namely RNAs and PUNAs, it is conceivable that management and use of such areas should differ. Whereas the RNAs were established for research and education, PUNAs were established for a different reason: enjoyment of the public.

Regarding management of RNAs, in Natural Areas of the Society of American Foresters (Buckman and Quintus *unknown date*) the following statements regarding RNA management were made: *"Public use of SAF natural areas, such as picnicking, camping,...hunting, fishing, and other such uses, may change the character of the area in such a way that its value for research and educational purposes is impaired or limited. These public uses as well as publicity that draws such uses to SAF natural areas are discouraged.****….****if roads or trails pass along a boundary of, or through an SAF natural area, limited posting is permitted in order to minimize encroachments…..Existing roads needed to administer contiguous lands or to facilitate research work in the natural area may be maintained. However, such maintenance, including the removal of dead and down timber, is limited to a strip not exceeding 30 feet on either side of the center line of such roads…..Wildfires originating within or adjacent to SAF natural areas are brought under control as quickly as possible. If such a fire burns within a natural area, clean-up, hazard reduction or reforestation is not undertaken unless the utility of the natural area is so seriously impaired that it will no longer be suitable as a natural area….Forest types and related vegetation which represent particular stages in succession may be maintained or created by practices such as prescribed burning."*

We suggest that the **ONLY** active management allowed in either PUNAs or RNAs be prescribed fire (mimicking a critical natural disturbance) in the SAF 15 Red Pine RNA and the White Pine PUNA, with consideration of management of invasive species (if they occur) in these and other areas as warranted.

(2) Management of the Seney Wilderness Area and Natural Areas —The Seney Wilderness Area constitutes Unit 4 of the refuge and represents, in many ways, the ideals of the *Wilderness Act* (1964). Roads are only found on the periphery and many of the ecosystems and habitat types found within the Wilderness Area are in near-benchmark condition. Conclusions from the NWRS-led *Report on Wilderness Character Monitoring, Seney Wilderness* (Carnes 2011) stated:

"A robust set of wilderness character monitoring measures were developed for Seney NWR between September and November 2011. The measures emphasize the Refuge's landscape-level management goals and their associated research. The measures also identify significant management activities occurring in wilderness, including wetland restoration and fire management. While the measures discussed in this document cannot possibly provide a complete picture of Seney's issues and resources, they capture an excellent snapshot of this 25,150-acre wilderness.

The overall condition of the Seney Wilderness is excellent. Refuge management has exerted significant effort to keep the natural systems intact and to allow most natural processes to function freely. The Seney Wilderness requires relatively few management actions, and very little recreational use occurs within its boundaries due to its remote nature. The chances of unauthorized actions taking place or of facilities being developed inside wilderness are therefore very slim.

The system of monitoring used for this project highlights a concern for the Seney Wilderness. I have recorded various aspects of the impacts and management actions relating to Walsh Ditch in 8 of the 31 measures. Walsh Ditch was developed prior to Seney's wilderness designation, forcing Refuge management to deal with its existence and inclusion as part of federally-designated wilderness. Refuge management chose to install earthen ditch plugs on Walsh Ditch with the intent of mitigating the ditch's damage to surrounding wetlands, while minimizing further degradation of wilderness character. However, certain degradations to both the undeveloped and untrammeled qualities were unavoidable in the process of the restoration project, making it difficult to balance the project's impacts and benefits among the four qualities of this monitoring system. While wetland restoration is an important and *admirable goal, so the inclusion of data regarding the amount/area of wetlands restored would be helpful within this particular monitoring framework. This would more explicitly display the restoration project's benefits to the natural quality, thus offsetting the degradations it causes to the undeveloped and untrammeled qualities.*

I believe that the wilderness character monitoring plan laid out in this document has taken into account many of the issues unique to the Seney Wilderness; may they be positive, negative, or neutral. The plan accounts for certain necessary degradations to one aspect of wilderness character by recording the positive results of such actions under another aspect. The plan responds to all nationally required wilderness character indicators, while taking care to include only measures that are actually relevant within the unique set of conditions at the Seney Wilderness. Additionally, the plan only uses data that is already routinely collected or is very simple to collect and analyze. It should be noted that, at first glance, the undeveloped and solitude qualities may seem less represented than the untrammeled or natural qualities. This was not done purposely for any type of bias among the four measures. The only reasons for this discrepancy are a lack of data sources and a lack of need. As for the former, there is no data, nor any system in place to collect data, on visitation to the wilderness, soundscape monitoring, or user-created recreation facilities. As for the latter, the time and effort of Refuge staff would not be well spent collecting data on such things as recreational campsites, old logging camps, or trails inside wilderness because these items either do not exist or do not have an impact in the Seney Wilderness. If for any reason these circumstances change, measures to represent their effects on wilderness character should be developed and entered into this framework.

In order to augment the areas where data were somewhat lacking, the following potential projects would benefit wilderness character monitoring in the future:

- *Initiation of a soundscape monitoring project*
- *Continuation of night sky brightness monitoring by purchasing a Sky Quality Meter (see Measure 27)*
- *Initiation of a protocol for estimating wilderness visitation (e.g. inquiring of visitors as to whether they will be visiting the wilderness when they come to the headquarters to obtain a gate key)*

- *Initiation of a protocol for estimating the number of user-created recreation facilities inside wilderness (e.g. hunting blinds)*
- *Initiation of a study regarding the amount/area of wetlands restored inside wilderness due to restoration efforts on Walsh Ditch*
- *Initiation of projects to improve wilderness awareness (e.g. brochures, kiosks, wilderness workshops etc.)*

While data from these projects would certainly aid in wilderness character monitoring, it is also understood that Refuge staff time is limited and is often stretched too thin. The addition of these projects may not be feasible in the near future, but they are nonetheless things to consider. Whether these projects are pursued or not, the primary conclusion that can be drawn from this project is that the Seney Wilderness is an excellent representation of wilderness qualities and values."

C. Potential refuge contribution to the habitat needs of the resources of concern. Within Michigan, Seney NWR is a significant contributor to the conservation of the bird species listed above. Within the NWRS and, more specifically the Midwest Region, the Natural Areas listed above are, in most cases, not replicated anywhere.

D. Reconciling conflicting habitat needs for resources of concern. During the Biological Review (2006) and CCP process, refuge staff considered the "pros and cons" of restoring acreage of native habitats and the loss of acreage of anthropogenic habitats, especially in regards to pools and old fields. An evaluation of resources of concern associated with the loss of some pools in Unit 2 and 3 indicated minimal impact on species associated with open water: wood turtle, mink frog, Osprey, Trumpeter Swans, and Common Loon. For instance, most of these bird species do not regularly rely on these pools for breeding, although Trumpeter Swans do nest successfully on these pools in some years (unpub. data). Nonetheless, with the retention of most open water in the refuge via Units 1 and 2, impacts are expected to be minimal. In a similar manner, it was thought that relatively little impact on native species diversity would result from the conversion of old fields back to native forests. Most species that may utilize those fields (e.g., Northern Harrier, Sharp-tailed Grouse, etc.) also are found in native open wetlands and the Diversion Farm, which will be conserved.

IV. Habitat Goals and Objectives (Desired Future Condition)

The CCP described and evaluated three management alternatives for the refuge. The preferred alternative was Alternative 2 (Habitat Management Gradient from a Conservation focus to the east, through a Restoration focus in much of the refuge core (Units 2 and 3), to Preservation in Unit 4, the Wilderness Area). This gradient of land management forms the basis for this HMP and definitions are provided above. As stated in the CCP and applicable to this HMP, habitat goals:

> **"Habitat – Conserve the range of habitat conditions now found within the refuge and (where and when possible) restore pre- European conditions once characteristic of the eastern UP."**

Objectives and strategies for habitat goals are listed below as an updated version from those listed in the CCP; no changes to acres affected were made.

A. Scrub-Shrub

Objective: Reduce this habitat type by 3,419 acres (-12%) from 2007 levels (28,954 acres). Manage the remaining 25,535 acres for the diversity of native species present. See Table 4 for associated *Resources of Concern* (if any).

Rationale: Historically, Seney NWR had large expanses of open fens that were dominated by *Carex* and other gramminoid species. This is clearly evident from aerial photographs taken in the 1930s. However, many years of fire suppression and altered hydrology have resulted in the encroachment of trees and shrubs into these open fens and bogs (Kowalski and Wilcox 2003; Welsh 2011; Bork *et al.* 2013), including the encroachment of the invasive shrub glossy buckthorn in much of Units 1-3.

Time and Measure of Success: Each year over the 15-year timing period of this HMP prescribed fire should be used (see Strategies, below) across units (see Strategies, below) to meet this objective, while working within the quantified NRV of fire (for the most part) in this landscape. That is, the quantified NRV of fire (e.g., fire return interval, rotation) should be applied across the units; only in Unit 1 should the NRV of fire be less of a consideration as this unit is drastically altered already. However, it is likely the lack of funding will limit the feasibility of broad-scale fire treatments (see Management Strategy Constraints and Limitations, below). Success should be measured by sites being within the NRV of vegetation and fire history, for the most part. However, the NRV of vegetation has yet to be quantified. A proposal has been submitted to the Joint Fire Science Program to do just this and relate patterns to fire history. Seney NWR is a co-PI of this proposal, led by D. Kashian (Wayne State Univ.).

B. Open Wetlands

Objective: Increase this habitat type by 23% or 3,847 acres from 2007 levels (16,617 acres). Manage the resulting 20,464 acres for the diversity of native species present. See Table 4 for associated *Resources of Concern* (if any).

Rationale: Sedge-bluejoint grasses and sphagnum-leatherleaf make up the greatest area in this habitat type. Open wetlands contain 13 known species of the genus *Carex*. Included within these areas of sedges are smaller pockets of bluejoint grass, cattail, leatherleaf, and sphagnum hummocks. Continued active management is necessary to maintain this important habitat type and prevent it from succeeding into scrub-shrub or other cover types (Kowalski and Wilcox 2003; Welsh 2011; Bork *et al.* 2013) and reduce the encroachment of the invasive shrub glossy buckthorn. Results of studies by J. Austin (USGS, *In Prep.*) are needed to further guide management and enhance prior work on inhabitants of this habitat type, such as the Yellow Rail (Bookhout and Stenzel 1987). Preliminary findings of the USGS-led work indicate Yellow Rail occupancy is greater in areas with 2 to 5" of water (the main driving factor), not too deep in spring, burned within the past 5 years, and in areas with good ground cover (i.e., litter mat and dense gramminoid growth) and relatively low shrub cover/heights. The shrub species in these sedge/shrub systems are generally tolerant of fire (especially leatherleaf) unless fire is severe enough to kill the growth points (near or just below the surface). A large-scale project at restoring hydrology and potentially open wetlands in Unit 3 is being initiated in conjunction with colleagues at Michigan Technological University (T. Pypker *et al. In Prep.*).

Time and Measure of Success: Each year over the 15-year timing period of this HMP prescribed fire should be used (see Strategies, below) across units (see Strategies, below) to meet this objective, while working within the quantified NRV of fire (for the most part) in this landscape. That is, the quantified NRV of fire (e.g., fire return interval, rotation) should be applied across the units; only in Unit 1 should the NRV of fire be less of a consideration as this unit is drastically altered already. However, it is likely the lack of funding will limit the feasibility of broad-scale fire treatments (see

Management Strategy Constraints and Limitations, below). Success should be measured by most sites being within the NRV of vegetation and fire history. The latter has been quantified, but not the former. A proposal has been submitted to the Joint Fire Science Program to do just this and relate patterns to fire history. Seney NWR is a co-PI of this proposal, led by D. Kashian (Wayne State Univ.). In 2012, treatments associated with a large-scale project aimed at reducing the acreage of anthropogenic pooled open water (and increasing acreage in open wetlands) will occur and be evaluated with ongoing applied research (T. Pypker *et al.* Michigan Technological Univ.).

C. Mixed Forests-Uplands

Objective: Maintain 2007 acreage (11,396 acres) and the diversity of seral stages, and (where and when possible) restore historic composition and structure for the diversity of native species present. See Table 4 for associated *Resources of Concern* (if any).

Rationale: This broad habitat type contains a wide range of forest conditions, including those composed primarily of early successional species. Much of the areas now comprised of this habitat type have undergone considerable alteration relative to pre-European times. Composition has been shifted to jack pine and some deciduous species, with a relatively uniform age structure (Corace *et al.* 2012a). This is markedly different than benchmark conditions (Corace *et al. In Press*). Future management should focus on promoting ecological integrity of these stands by (in most instances) promoting compositional and structural diversity and move succession forward to emulate later seral stage characteristics (see below).

Time and Measure of Success: Each year over the 15-year timing period of this HMP prescribed fire should be used (see Strategies, below) across units (see Strategies, below) to meet this objective, while working within the quantified NRV of fire (for the most part) in this landscape. That is, the quantified NRV of fire (e.g., fire return interval, rotation) should be applied across the units. However, it is likely the lack of funding will limit the feasibility of broad-scale fire treatments (see Management Strategy Constraints and Limitations, below). Mechanical treatments of altered sites should occur when feasible. Success should be measured by sites being within the NRV of vegetation and fire history. Because most of the acreages in this habitat type was historically less dominated by deciduous species and were more upland coniferous forest (that is, mixed forests-uplands are primarily former coniferous forest-upland sites that have been invaded by aspen and other species), the NRV of our mixed-pine sites (see above and below) provide benchmarks.

D. Coniferous Forests-Uplands

Objective: Increase acreage from 2007 levels (8,857 acres) by 95 acres to 8,952 acres (+1%), maintain diversity of seral stages, and restore historic composition and structure when and where possible for the diversity of native species present (see below). See Table 4 for associated *Resources of Concern* (if any).

Rationale: These forests were also common elsewhere in the pre-European landscape of the northern Lake States, with approximately 10 million acres of the region dominated by mixed-pine or similar forest ecosystems (Benzie 1977). However, many of the sites in the northern Lake States have been converted to monotypic, artificially regenerated pine plantations. In other cases, such as at Seney NWR, turn-of-the-century logging, wildfires outside the natural range of variation, and subsequent fire suppression have altered the structure and composition of the remaining naturally regenerated, second-growth stands (Drobyshev *et al.* 2008b). Of the upland habitat types on the refuge, upland coniferous forests have the greatest potential for restoration (Rist 2008; Corace *et al.* 2012a). Most forest stands in this habitat type consisted of long lived red and eastern white pine, with a minor component of jack pine, aspen, and other overstory species (Drobyshev *et al.* 2008b; Corace et al. *In Press*). Fortunately, the refuge has remote pine islands that were never harvested and these serve as benchmarks for restoration of this habitat type. Future management should focus on promoting ecological integrity of these stands and (where and when possible) restore composition and structure to benchmark conditions (Drobyshev *et al.* 2008a,b; Corace *et al.* 2009; Corace *et al. In Press*) (Figure 8; Tables 5 and 6, below). No invasive species were found during the work of Corace *et al.* (2012b) or during other work in this habitat type.

Time and Measure of Success: Each year over the 15-year timing period of this HMP prescribed fire should be used (see Strategies, below) across units (see Strategies, below), while working within the quantified NRV of fire (for the most part) in this landscape. That is, the quantified NRV of fire (e.g., fire return interval, rotation) should be applied across the units where reference sites exists. However, it is likely the lack of funding will limit the feasibility of this (see Management Strategy Constraints and Limitations, below). Mechanical treatments of altered sites should occur when feasible. Success should be measured by sites being within the NRV of vegetation and fire history (see above and below). A dissertation (Ohio State Univ.) is being defended in spring 2013 that investigates the efficacy of variable retention treatments to regenerate red pine and eastern white pine. The georeferenced sample points produced in that work provide opportunities for later evaluation/research.

Figure 8. Diameter class distributions of trees (left) and snags (right) in 38 reference (above) and 47 altered (below) 500 m^2 mixed-pine plots at Seney NWR. The category "pine species" includes red, white, or jack pines that could not be identified to one species. "Non-pines" species consist of deciduous species and some other conifers (Corace *et al. In Press*). Reference stands represent desired future condition.

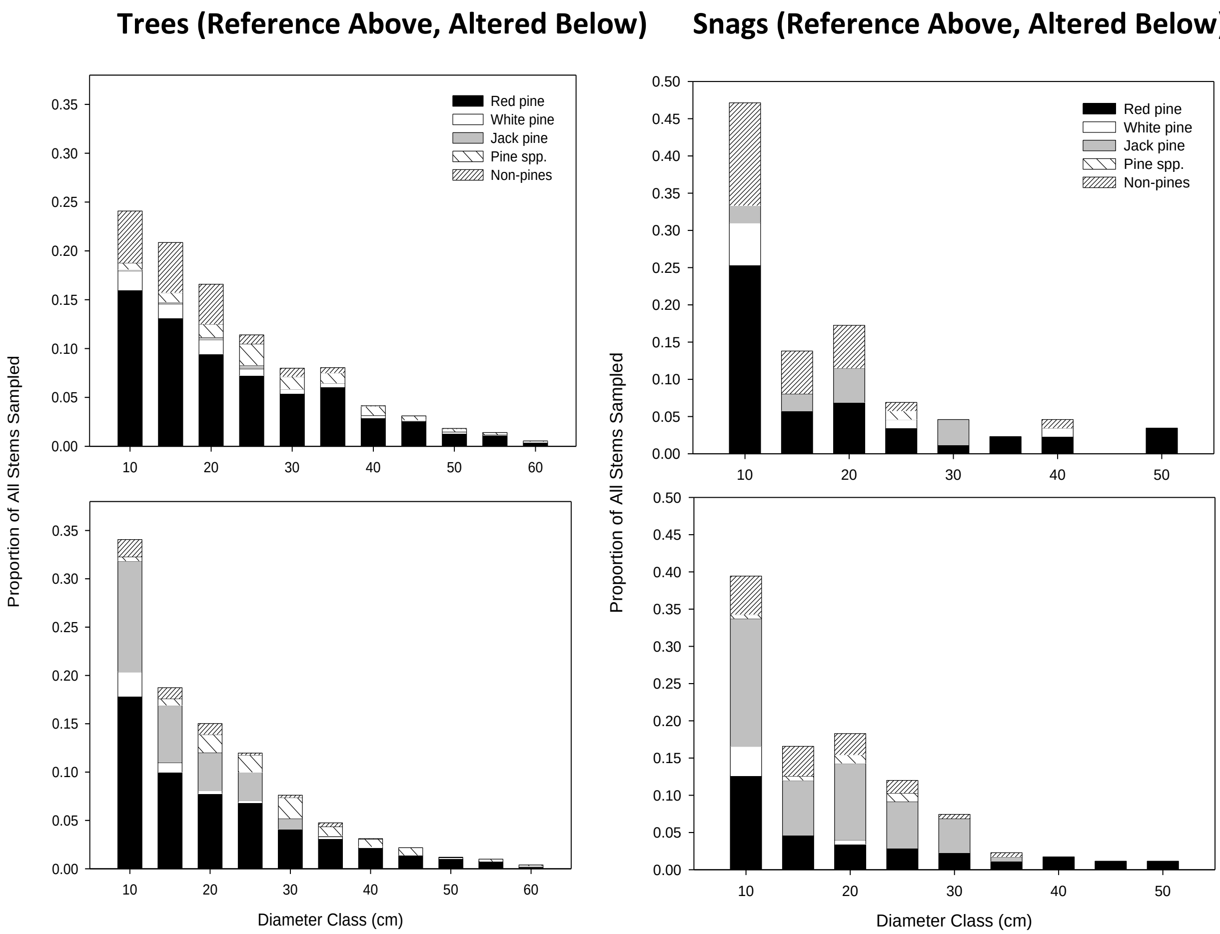


Table 5. Characteristics of live trees and snags in reference and altered mixed-pine plots at Seney NWR (Corace *et al. In Press*) (data are in metric units).

Variable	Reference (*n* = 38)	Altered (*n* = 46)	df	*t* (*P*)
Total no. of snags	87	175		
Total no. of live trees	1640	2023		
Mean (±1SD) dbh (cm)				
Snags	21.5 (9.8)	22.1 (9.6)	70	0.30 (0.77)
Live Trees	25.2 (4.3)	23.1 (4.3)	82	2.16 (0.03)
Mean (±1SD) density (stems ha^{-1})				
Snags	45.8 (35.1)	76.1 (77.8)	82	1.49 (0.14)
Live Trees	863.2 (279.6)	879.6 (363.4)	82	0.02 (0.98)
% snags of total	6.1 (5.7)	10.6 (13.4)	82	1.41 (0.16)
Mean (±1SD) basal area (m^2 ha^{-1})				
Snags	1.8 (1.7)	2.9 (2.8)	82	2.11 (0.04)
Live Trees	48.8 (11.4)	41.7 (12.3)	82	2.72 (0.005)
% of total basal area snag	4.0 (4.1)	8.1 (10.6)	82	1.93 (0.06)

Table 6. Rapid ecological assessment summary data (mean, ±1SD) across plots within three pine-dominated altered stands at Seney NWR (Corace *et al.* 2012b) and one near-benchmark stand (Red Pine RNA, unpub. data).

Stand Name or Code	Trees per Acre	Tree Basal Area (ft^2/ac)	Tree DBH (in)	Tree Crown Class[a]	Percent (%) Closed Canopy	Snags per Acre	Snag DBH (in)	Percent (%) of Plots with Coarse Woody Debris
D-CUT	133.3±107.6	85.5±90.1	9.9±3.0	2.3±0.3	67.3±14.9	11.4±22.4	11.0±5.0	48
D-PINE	194.3±94.9	120.8±86.2	10.8±4.8	1.9±0.4	83.5±5.8	28.6±49.2	6.8±1.8	19
D-C2O	26.7±46.2	18.7±32.5	11.4±0.4	1.0±0	32.3±37.4	0±0	0±0	0
RPRNA (Red Pine RNA)	164.4±99.8	102.2±84.0	9.9±3.0	1.7±0.4	77.9±16.0	31.1±48.6	9.3±3.4	5.6

[a]Crown class codes (numeric value): 1= dominant, 2= co-dominant, 3= intermediate, 4= suppressed.

E. Mixed Forests-Lowlands

Objective: Maintain 2007 acreage (8,221), diversity of seral stages, and (where and when possible) restore historic composition and structure for the diversity of native species present. See Table 4 for associated *Resources of Concern* (if any).

Rationale: It is unknown how altered this habitat type is at the refuge, relative to its historic condition; **patterns associated with the NRV have not been quantified**. Since refuge establishment, relatively little active management has occurred in this habitat type (Rist 2008). Future management should focus on assessing the condition of this habitat type and promote ecological integrity of these stands. Restoration of hydrology may be a key consideration.

Time and Measure of Success: No active management is proposed in the next 15 years.

F. Coniferous Forests-Lowlands

Objective: Maintain 2007 acreage (7,825 acres), diversity of seral stages, and (where and when possible) restore historic composition and structure for the diversity of native species present. See Table 4 for associated *Resources of Concern* (if any).

Rationale: Other than the cutting of white cedar trees for boundary posts, relatively little active management has occurred in this habitat type (Rist 2008). Changes, however, to the hydrology at the refuge have likely adversely impacted this habitat type in some areas. Tamarack, for instance, may be less of a component of some forest stands due to hydrologic alterations; in other locations, altered hydrology has moved tamarack into formerly open wetlands. Restoring the hydrology of some areas may help restore this species in some sites and reduce its dominance in others. Future management should focus on promoting ecological integrity of these stands (Table 7). No invasive species were found during the work of Corace *et al.* (2012b).

Time and Measure of Success: No active management is proposed in the next 15 years.

Table 7. Rapid ecological assessment summary data (mean, ±1SD) across plots within two eastern hemlock-dominated stands at Seney NWR, including the Hemlock RNA (HRNA, Corace *et al.* 2012b; unpub. data). This represents near-benchmark and desired future condition.

Stand Name or Code	Trees per Acre	Tree Basal Area (ft^2/ac)	Tree DBH (in)	Tree Crown Class[a]	Percent (%) Closed Canopy	Snags per Acre	Snag DBH (in)	Percent (%) of Plots with Coarse Woody Debris
HEM	250.0±38.3	358.4±64.7	14.7±1.7	2.8±0.3	86.9±3.6	0±0	0±0	75
HRNA (Hemlock RNA)	178.5±58.0	203.3±131.3	13.0±4.9	2.1±0.4	96.6±1.9	30.8±40.5	12.1±7.3	30.8

[a]Crown class codes (numeric value): 1= dominant, 2= co-dominant, 3= intermediate, 4= suppressed.

G. Open Water

Objective: Reduce acreage from 2007 level (5,104 acres) by 428 acres (-8%), and manage remaining 4,676 acres for the diversity of native species present. See Table 4 for associated *Resources of Concern* (if any).

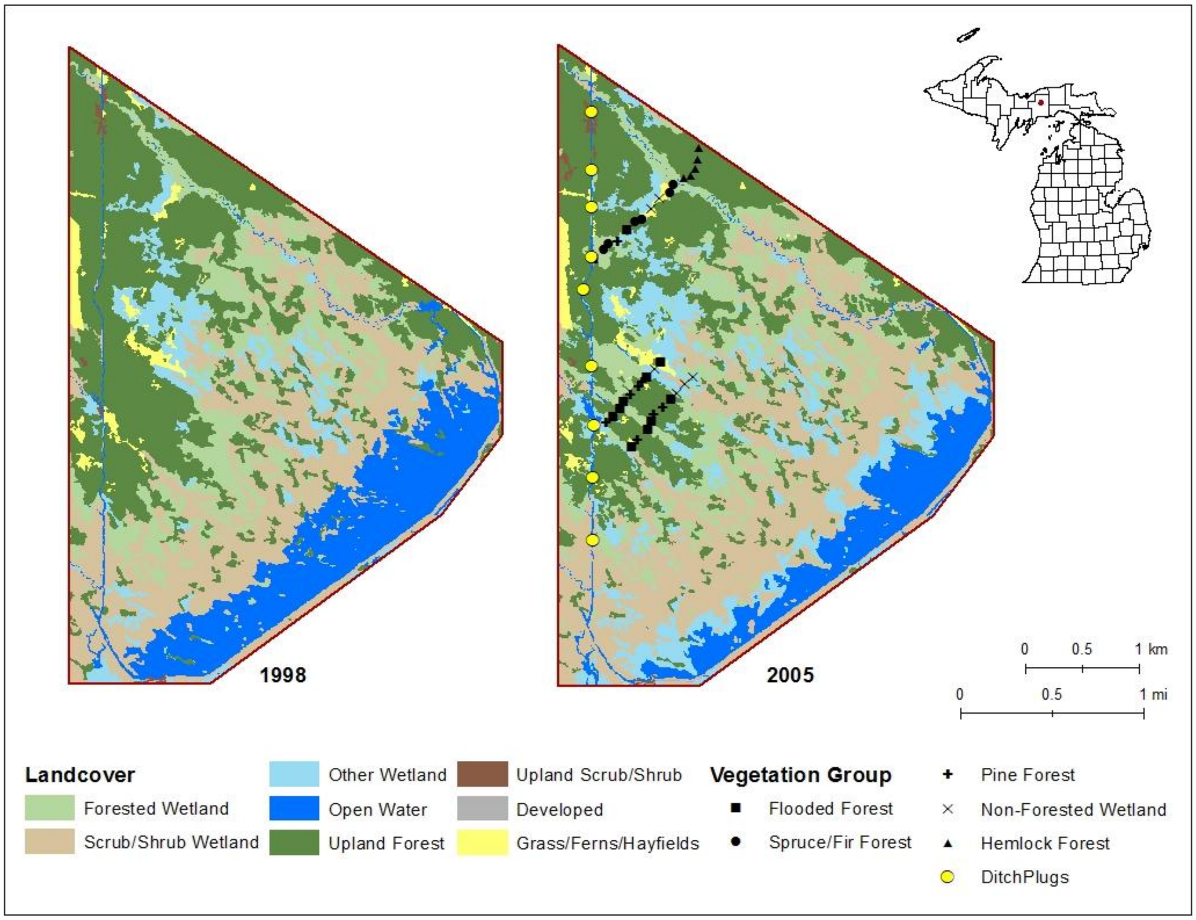
Rationale: Except for American beaver ponds and streams, open water was not very prominent on the landscape prior to refuge establishment. According to refuge notes, there was only one named body of water on the refuge, which was located near M-2 Pool. Today, **the majority of area in this habitat type is mainly confined to the refuge's 27 pools, of which 21 have water control capability.** Other sources of open water consist of American beaver ponds and the creeks, ditches, and rivers that supply the pools. Submerged aquatic vegetation and associated invertebrates provide essential food for waterbirds. Submergents are present throughout, but reach their greatest densities in open bays free of emergents. The refuge has documented over 35 species of submergents, including 16 species of pondweed.

Future management should strive to emulate the patterns of open water produced by American Beaver, which past studies on the refuge have shown provide habitat for a broad-range of wildlife species (Beard 1953). **As such, there should be consideration of managing American beaver populations differently across the landscape.** Unless American beaver activity threatens the integrity of dikes, their impacts should be viewed positively in most instances in Units 2-4. Management should also continue to evaluate the need for reducing the negative impact of ditches (Bork *et al.* 2013) (Figure 9). Moreover, Unit 3 pools (between C-3 Pool and Marsh Creek Pools) and T-2 East Pool should be removed and hydrologic research and monitoring done in conjunction with colleagues at Michigan Technological University (T. Pypker).

Time and Measure of Success: Each year over the 15-year timing period of this HMP an annual water management plan should be prepared that meets Strategies (see below). Because most open water is basically an anthropogenic habitat type there is no NRV of water levels. However, gradual draw downs will likely occur most years as the later summer is a drier period at Seney NWR. Success should be measured by maintaining 235 Trumpeter Swans (breeding and non-breeding) on average per year over the 15-year planning period per data presented by Corace *et al.* (2006) and subsequent monitoring data. For Common Loons, success will be measured by maintaining 13 territorial pairs

(1987-2011 long-term average) (D. McCormick, unpub. data). In 2012, treatments associated with a large-scale project aimed at reduced the acreage of anthropogenic pooled open water (and increasing acreage in open wetlands and concomitantly scrub-shrub and lowland coniferous forests) will occur and evaluated with ongoing applied research (T. Pypker et al. Michigan Technological Univ.).

Figure 9. Change (1998 and 2005) in total area of each cover type associated with changing landscape patterns brought about by ditch plugs in the Walsh Ditch area north of C-3 Pool. Black dots along transects are sampling points (Bork *et al.* 2013).



H. Deciduous Forests-Uplands

Objective: Increase deciduous forest acreage from 2007 levels (4,372 acres) by 232 acres (+5%) and manage the resulting 4,600 acres to maintain the diversity of seral stages and (where and when possible) restore historic composition and structure for the diversity of native species present. See Table 4 for associated *Resources of Concern* (if any).

Rationale: This habitat type is found in scattered stands at the refuge, usually on the best upland soils. Prior logging for exploitive and utilitarian reasons has degraded stand composition and structure relative to pre-European benchmark conditions. Late successional stages of this habitat type have, in particular, undergone considerable alteration. In most late successional stands, composition has been shifted from a mixed forest community to one primarily dominated by shade-tolerant maple species (Table 8-10). Fewer individuals of species such as yellow birch, eastern white pine, eastern hemlock, and white spruce are now found. Beech Bark Disease has further exacerbated these problems by causing mortality in one of the few native hard mast-producing species at the refuge (American beech); as suggested by data, this mortality has led to a spike in deadwood in these stands (Table 8). Future management should focus on promoting ecological integrity of these stands by mitigating for Beech Bark Disease, emulating gap dynamics, promoting compositional and structural diversity, and (in most instances) move succession forward to emulate later seral stage characteristics (Corace *et al.* 2009). No invasive species were found in stands of this habitat type that were sampled during the work of Corace *et al.* (2012b), but some species (forget-me-not) have moved in since.

Time and Measure of Success: A timber sale to mitigate for effects of Beech Bark Disease is planned for in 2013. Treatments to convert fields to this habitat type occurred in 2011/2012. Success in the former should be measured by patterns emulating desired future conditions (see below).

Table 8. Average (±1SD) values across plots within northern hardwood-dominated stands at Seney NWR (Corace *et al.* 2012b). SH-R and SH-N are in the Northern Hardwood RNA and HARD is the Northern Hardwood PUNA. These three stands represent near-benchmark and desired forest condition, although Beech Bark Disease is impacting these stands (note the deadwood data).

Stand Name or Code	Trees per Acre	Tree Basal Area (ft^2/ac)	Tree DBH (in)	Tree Crown Class[a]	Percent (%) Closed Canopy	Snags per Acre	Snag DBH (in)	Percent (%) of Plots with Coarse Woody Debris
COF	60.0±33.5	75.4±56.5	14.5±6.8	2.4±0.2	93.7±1.6	13.3±20.7	18.4±6.4	67
SH-R (Northern Hardwood RNA)	177.8±75.1	127.0±79.2	10.7±3.8	2.4±0.4	91.4±2.7	22.2±21.1	15.5±7.5	67
SH-N (Northern Hardwood RNA)	151.1±79.4	120.4±75.7	12.1±3.1	2.7±0.6	91.5±2.6	13.3±40.0	13.3±0	44
CHF-TA	106.7±40.0	117.2±48.2	13.9±4.1	2.2±0.2	95.5±0.9	8.9±17.6	13.2±9.6	56
CHF-TB	200.0±109.5	163.8±88.8	11.9±3.9	2.3±0.4	94.4±1.4	8.9±17.6	8.9±1.1	67
HARD (Northern Hardwood PUNA)	235.0±189.4	137.9±63.9	12.0±6.4	2.5±0.4	88.9±4.2	40.0±42.8	7.1±0.9	88
WILD (Wilderness Area Hardwoods)	163.1±90.1	104.9±50.2	10.7±3.2	2.4±0.2	93.3±2.9	12.3±19.2	7.6±4.4	54

[a]Crown class codes (numeric value): 1= dominant, 2= co-dominant, 3= intermediate, 4= suppressed.

Table 9. Overstory composition, Importance Values, and related measures across plots within northern hardwood-dominated stands at Seney NWR (Corace *et al.* 2012b). Note the maple dominance.

Stand Name or Code	Species or Species Group [a]	Relative Frequency (F, %)	Relative Density (D, %)	Relative Dominance (Do, %)	Importance Value (F + D + Do / 3, %)
COF	sugar maple	66.7	77.8	63.3	69.3
	yellow birch, white ash	33.3	22.2	36.7	30.7
SH-R (Northern Hardwood RNA)	maple	61.5	70.0	79.9	70.5
	paper birch	23.1	20.0	16.4	19.8
	balsam fir, American beech	15.4	10.0	3.7	9.7
SH-N (Northern Hardwood RNA)	maple	50.0	55.9	69.9	58.6
	American beech	33.3	38.2	27.2	32.9
	yellow birch	16.7	5.9	2.9	8.5
CHF-TA	maple	61.5	72.0	80.9	71.5
	yellow birch, American beech	38.5	28.0	19.1	28.5
CHF-TB	sugar maple	37.5	55.6	63.3	52.1
	Oregon ash	31.3	24.4	10.4	22.0
	hop-hornbeam, bigtooth aspen, American basswood, etc.	31.3	20.0	26.3	25.9
HARD	bigtooth aspen	23.5	55.3	45.6	41.5
	maple	35.3	21.3	20.9	25.8
	paper birch	17.6	8.5	13.6	13.2
	eastern hemlock	5.9	8.5	7.7	7.4
	eastern white pine, American beech	17.6	6.4	12.3	12.1
WILD (Wilderness Area Hardwoods)	maple	61.9	83.0	82.5	75.8
	American beech	28.6	13.2	11.4	17.7
	eastern hemlock, black cherry	9.5	3.8	6.2	6.5

[a]Importance Values were calculated for those species (or species groups) with ≥4 individual stems per transect. Rarer species were lumped and values shown.

Table 10. Midstory and understory summary across plots within northern hardwood-dominated stands at Seney NWR (Corace *et al.* 2012b).

Stand Name or Code	Mean (±SD) Number Woody Plant Stems < 5" DBH	Mean (±SD) Herbaceous Plant Cover[a]
COF	0.5±0.8	1.3±0.4
SH-R (Northern Hardwood RNA)	2.8±4.2	1.1±0.7
SH-N (Northern Hardwood RNA)	1.6±1.9	1.3±0.7
CHF-TA	0.4±0.7	1.0±0.7
CHF-TB	0.6±1.3	1.9±0.9
HARD	0.1±0.3	1.1±1.0
WILD (Wilderness Area Hardwoods)	1.0±1.1	0.8±0.7

[a]Cover class codes (numeric value): T= trace (0), 1-25% (1), 26-50% (2), 51-75% (3), >75% (4).

I. Deciduous Forests-Lowlands

Objective: Maintain acreage at 2007 levels (2,515 acres), diversity of seral stages, and (where and when possible) restore historic composition and structure for the diversity of native species present. See Table 4 for associated *Resources of Concern* (if any).

Rationale: This habitat type has seen relatively little management in the past and is not considered drastically altered relative to pre- European conditions; **however, the NRV has not been quantified**. Future management should focus on gap dynamics and promoting composition and structural diversity while allowing succession to proceed in most areas.

Time and Measure of Success: No active management is proposed in the next 15 years.

J. Upland Old Fields and Openland

Objective: Reduce openland habitat from 2007 levels (1,302 acres) by 327 acres (-25%) and manage the remaining 979 acres for the diversity of native species present. See Table 4 for associated *Resources of Concern* (if any).

Rationale: This habitat type consists of primarily anthropogenic habitats created prior to refuge establishment. Many non-native grass species, such as Kentucky bluegrass and several brome species, characterize these areas. Other than Diversion Farm (which because of its size and location offers habitat for a number of bird species), the other fields should be either allowed to naturally succeed to deciduous (or mixed) forests or be actively managed to do so.

Time and Measure of Success: Treatments to promote natural secondary succession occurred in 2011 and 2012 (see Appendix A). Mowing of Diversion Farm should focus on reducing dominance of invasive plants (see Appendix G). Success for the former sites (e.g., Conlon, Smith, Sub-Headquarters, and Chicago Farms) should be measured by sites slowly converting to forest cover (no forest cover existed during treatments, assessments can be made in 15 years), with the reverse being true at Diversion Farm. However, as natural secondary succession is the main process and it is well established that sites become forested over time, patience is key and monitoring is of low priority.

K. Invasive Species Management

Objective: By 2020, reduce the area infested with target invasive plant species (e.g., glossy buckthorn, tartarian honeysuckle, multiflora rose) by 50% from the documented 2007 level (using amount herbicide applied and staff hours as proxies) and eliminate new infestations of these and other highly invasive species as they occur. See Table 4 for associated *Resources of Concern* (if any).

Rationale: Many exotic plants and pathogens have been identified at the refuge, with many being invasive (see Appendix G). Most of the invasive species of priority are found in Unit 1 where the hydrology is most altered and the most development (pools, roads, buildings) and vehicle traffic exists. Glossy buckthorn, a primary species for management, has invaded anthropogenic and native wetland habitats at Seney NWR and the negative effects of this species in similar wetlands in Michigan include lower soil pH, fewer vegetative hummocks, less light availability, lower plant coefficient of conservation, less total plant cover, and lower graminoid dominance (Fiedler and Landis 2012).

Refuge forests are almost devoid of invasive plants (Corace *et al.* 2012b), but hardwood forests do have issues with non-native pathogens involved in the Beech Bark Disease complex. In Units 2-4, invasive plants are relatively uncommon (Cohen and Slaughter 2007; Welsh 2011; Bork *et al.* 2013). Nonetheless, more invasive species are expected to arrive in the future. Management should therefore strive to assess the threat these species have on native ecosystem/habitat structure and function and (for those species that constitute the greatest threats) an active management and monitoring program should ensue (see Appendix G). Although invasive animals are less of a problem at Seney NWR, recent studies have documented the distribution, abundance, and potential effects of non-native earthworms at the refuge (Shartell 2012a; Shartell *et al.* 2012). Studies in similar forest ecosystems elsewhere in the northern Lake States have suggested that these organisms may have numerous deleterious effects on northern hardwood communities, including ground-nesting songbirds (Loss and Blair 2011).

Time and Measure of Success: See Appendix G.

V. Habitat Management Strategies and Spatial (Unit) Focus

A. Scrub-Shrub

Strategies:

1. Modify annual burn plans to delineate target areas and target acres.
2. Add 122 acres by eliminating Spur Pools and Delta Creek Pool and then monitor and study succession (ongoing study with T. Pypker, Michigan Technological Univ.).
3. In Unit 1, reduce acreage by 1,002 (north end of Unit) by using prescribed fire to promote herbaceous plants and stress woody plants (growing season burns, preferably).
4. In Unit 2, reduce acreage by 886 (A-2 Pool area) by using prescribed fire to promote herbaceous plants and stress woody plants (growing season burns, preferably).
5. In Unit 3, reduce acreage by 1,653 (Marsh Creek Pool and C-3 Pool areas) by using prescribed fire to promote herbaceous plants and stress woody plants (growing season burns, preferably).

Spatial (Unit/LTA) Focus: Active management to reduce acreage of scrub-shrub should occur in Units 1-3 and across all LTAs other than the Manistique Lakes Segment. Staff should investigate applying prescribed fire in Unit 4 (Wilderness Area).

B. Open Wetlands

Strategies:

1. Continue research that promotes the understanding of how this habitat type functions and its NRV. Variables to be measured should include hydrology, soils, and vegetation response to management actions.
2. Use prescribed and natural fire, where and when appropriate (3,541 acres), to promote herbaceous vegetation and stress woody vegetation (growing season burns, preferably).
3. In Unit 2, add 306 acres in T-2 East Pool by removing standing water (removing dike).
4. Remove trees growing on dikes to reduce evapotranspiration and water loss in adjacent wetland and reduce unnatural linear landscape patterns.

Spatial (Unit/LTA) Focus: Active management to increase acreage of open wetlands should occur in Units 1-3 and across all LTAs other than the Manistique Lakes Segment. Staff should investigate applying prescribed fire in Unit 4 (Wilderness Area).

C. Mixed Forests-Uplands

Strategies:

1. Understand the natural disturbance regime inherent to the forest types within this broad habitat and work within the confines of seral pathways dictated by soil, climate, and hydrology.
2. Promote stands dominated by early seral stages of mixed forest at the refuge periphery by mechanical treatments (including timber sales) and prescribed and managed wildfire.
3. Promote stands dominated by later seral stages of mixed forest in the refuge interior by mechanical treatments (including timber sales) and prescribed and managed wildfire (ongoing research with C. Goebel, Ohio State Univ.).
4. In managed stands, promote increased compositional and structural heterogeneity as described above (see Figure 8; Tables 5 and 6), including large-diameter coarse woody debris and snags.
5. Use management techniques that emulate natural ecological disturbances (e.g., single tree mortality for multi-aged stands, stand/cohort replacement for even-aged stands).
6. Use commercial (timber harvests) and non-commercial (hydro-ax or similar) mechanical treatments, where and when appropriate.
7. Use prescribed and natural fire, where and when appropriate.
8. Ensure white-tailed deer populations do not negatively affect the habitat.
9. Manage invasive species aggressively (see below).

Spatial (Unit/LTA) Focus: Active management aimed at restoring historic patterns should focus on Units 2-3 (especially upland sites in the Seney Channel Fens and the Strangmoor Bog LTAs), with conservation of patterns within the NRV in Unit 1. Passive management (preservation) should occur in Unit 4 (Wilderness Area).

D. Coniferous Forests-Uplands

Strategies:

1. Understand and emulate the natural disturbance regime inherent to the forest types within this broad habitat type and work within the confines of seral pathways dictated by soil, climate, and hydrology.
2. Increase 95 acres from West Walsh Farm and East Walsh Farm by passive management and natural secondary succession.
3. Promote stands dominated by early seral stages at the refuge periphery by mechanical treatments (including timber sales) and prescribed and managed wildfire.
4. Promote stands dominated by later seral stages in the refuge interior by mechanical treatments (including timber sales) and prescribed and managed wildfire.
5. In managed stands, promote increased compositional and structural heterogeneity, including large-diameter coarse woody debris and snags (see Figure 8; Tables 5 and 6).
6. Use management techniques that emulate natural ecological disturbances (e.g., single tree mortality for multi-aged stands, stand replacement for even-aged stands).
7. Use commercial and non-commercial mechanical treatments, where and when appropriate.
8. Use prescribed and natural fire, where and when appropriate. **Note:** avoid any use of fire in “stump fields” or former mixed-pine sites that were logged and burned severely around the turn of the century. These areas are demarcated by scattered eastern white pine and are found along the main upland areas adjacent to refuge roads. Burning in these sites will reduce soil productivity which was drastically altered over 100 years ago.
9. Ensure white-tailed deer populations do not negatively affect the habitat.
10. Manage invasive species aggressively (see below).

Although stem mapping was done as part of the Drobyshev *et al.* (2008a,b), no analyses of these data has yet been done. Nonetheless, many studies of fire-dependent coniferous forest suggest management efforts should focus on spatial heterogeneity (Larson and Churchill 2012).

Recommendations include:

a. Create a patchwork of openings, single trees, and clumps of overstory trees with adjacent or interlocking crowns;
b. Retain all old growth;
c. Avoid any arbitrary diameter limits for harvests;
d. Leave more trees per clump in second growth stands;
e. Retain clumps of seedlings and saplings when they do not act as ladder fuels;
f. Any planting should produce patterns as described above (openings, clumps, etc.);
g. Allow local accumulation of downed materials;
h. Harvests should produce heterogeneous downed fuel conditions.

Spatial (Unit/LTA) Focus: Active management aimed at restoring historic patterns should focus on Units 2-3 (especially upland sites in the Seney Channel Fens and the Strangmoor Bog LTAs), with conservation of patterns within the NRV in Unit 1. Passive management (preservation) should occur in Unit 4 (Wilderness Area).

E. Mixed Forests-Lowlands

Strategies:

Although no active management is called for during the lifespan of this HMP (some minor impacts by prescribed fire are possible), the following should be considered in any future management:

1. Understand and emulate the natural disturbance regime (see below) inherent to the forest types within this broad habitat type and work within the confines of seral pathways dictated by soil, climate, and hydrology.
2. In managed stands, promote increased compositional and structural heterogeneity, including large-diameter coarse woody debris and snags.
3. Use management techniques that emulate natural ecological disturbances (e.g., single tree mortality in some instances and stand replacement in other instances).
4. Use commercial and non-commercial mechanical treatments, where and when appropriate.
5. Use prescribed and natural fire, where and when appropriate.
6. Ensure white-tailed deer populations do not negatively affect the habitat.
7. Manage invasive species aggressively (see below).

Spatial (Unit/LTA) Focus: Future active management aimed at restoring historic patterns should focus on Units 2-3 (especially upland sites in the Seney Channel Fens and the Strangmoor Bog LTAs), with conservation of patterns within the NRV in Unit 1. Passive management (preservation) should occur in Unit 4 (Wilderness Area).

F. Coniferous Forests-Lowlands

Strategies:

Although no active management is called for during the lifespan of this HMP (some minor impacts by prescribed fire are possible), the following should be considered in any future management:

1. Understand and emulate the natural disturbance regime inherent to the forest types within this broad habitat type and work within the confines of seral pathways dictated by soil, climate, and hydrology.
2. In managed stands, promote increased compositional and structural heterogeneity, including large-diameter coarse woody debris and snags (see Table 7).
3. Use management techniques that emulate natural ecological disturbances (e.g., single tree mortality in some instances and stand replacement in other instances).
4. Use commercial and non-commercial mechanical treatments, where and when appropriate.
5. Use prescribed and natural fire, where and when appropriate.
6. Ensure white-tailed deer populations do not negatively affect the habitat.
7. Manage invasive species aggressively (see below).

Spatial (Unit/LTA) Focus: Future active management aimed at restoring historic patterns should focus on Units 2-3 (especially upland sites in the Seney Channel Fens and the Strangmoor Bog LTAs), with conservation of patterns within the NRV in Unit 1. Passive management (preservation) should occur in Unit 4 (Wilderness Area).

G. Open Water

Strategies:

1. Remove the dikes at Spur Pools, Delta Creek Pool, and T-2 (East) Pool. Conduct appropriate biotic and abiotic monitoring, before, during, and after these projects (ongoing study with T. Pypker, Michigan Technological Univ.).
2. Maintain all remaining water control infrastructure.

3. To reduce negative impacts on surrounding open wetlands and refuge infrastructure such as increased evapotranspiration and unnatural landscape patterns, remove trees from dikes. Maintain "pine islands" that are connected by the dike system.
4. Manage "nuisance" American beaver populations differently across the landscape, with more aggressive management in Unit 1 and no active management in Unit 4. Integrate any trapping into educational programs when possible and appropriate.

Spatial (Unit/LTA) Focus: Active management is primarily aimed at Units 1-3 (especially the Seney Channel Fens and the Strangmoor Bog LTAs), with decreasing emphasis in Unit 3 (Spur Pools removed). Passive management (preservation) should occur in Unit 4 (Wilderness Area).

H. Deciduous Forests-Uplands

Strategies:

1. Understand the natural disturbance regime inherent to the forest types within this broad habitat type and work within the confines of seral pathways dictated by soil, climate, and hydrology.
2. Eliminate the following old fields that exist on soils in which the native cover is deciduous forest (either passively by allowing forest succession to occur or promote forest succession by plantings, see Appendix A): Smith Field (22 acres), Sub-Headquarters Field (64 acres), Conlon Farm (39 acres), Chicago Farm (97 acres), and miscellaneous forest openings (10 acres).
3. In managed stands, promote increased compositional and structural heterogeneity, including large-diameter coarse woody debris and snags (see Table 8-10).
4. Promote early seral stages dominated by aspen at the refuge perimeter using mechanical treatments (commercial timber sales and other) and prescribed and managed wildfire.
5. Stands with late seral characteristics should be conserved wherever they exist, and restored in the interior of the refuge.
6. Enhance representation of more uncommon species such as yellow birch, eastern white pine, and eastern hemlock, and conserve as much American beech as possible. Using mechanical means, open the canopy, reduce dominance of red and sugar maple, and provide some scarification. Using yellow birch, eastern white pine, and eastern hemlock trees as "crop trees" in these stands would be one way to promote these species (more sunlight on retained stems means generally more seed production).

7. Use management techniques that emulate natural ecological disturbances (e.g., single tree mortality in late seral stands).

8. Use commercial and non-commercial mechanical treatments, where and when appropriate.

9. Ensure white-tailed deer populations do not negatively affect the habitat.

10. Manage invasive species aggressively (see below).

11. Continue to monitor spread of beech bark disease and treatment effectiveness as part of a state-wide monitoring system involving Michigan State Univ. (D. McCullough) and Michigan Technological Univ. (A. Storer).

Spatial (Unit/LTA) Focus: Management aimed at restoring historic patterns should focus on Units 2-3 (especially upland sites in the Seney Channel Fens and the Strangmoor Bog LTAs), with conservation of patterns within the NRV in Unit 1. Passive management (preservation) should be done in Unit 4 (Wilderness Area).

I. Deciduous Forests-Lowlands

Strategies:

Although no active management is called for during the lifespan of this HMP (some minor impacts by prescribed fire are possible), the following should be considered in any future management:

1. Understand and emulate the natural disturbance regime inherent to the forest types within this broad habitat type and work within the confines of seral pathways dictated by soil, climate, and hydrology.

2. Ensure white-tailed deer populations do not negatively affect the habitat.

3. Manage invasive species aggressively (see below).

Spatial (Unit/LTA) Focus: Passive management (preservation) across Units 1-4 and all LTAs.

J. Upland Old Fields and Openland

Strategies:

1. Conserve Diversion Farm using a combination of tools, including prescribed fire and mowing.

2. Elsewhere, reforest (afforestation) fields to upland deciduous forest stands either passively through natural secondary succession or through active management that could include planting of seedlings. **Note:** avoid any use of fire as this will only further promote the sod layer.

3. Remove all plantations existing of trees not naturally adapted to these sites (e.g., red pine).

4. Ensure white-tailed deer populations do not negatively affect the habitat
5. Manage invasive species aggressively (see below).

Spatial (Unit/LTA) Focus: Active or passive management to decrease acreage of old fields should occur primarily in Unit 1-2 (upland sections of the Manistique Lakes Segment LTA).

K. Invasive Species Management

Strategies:

1. When available, use biological control or passive management as a preferred strategy. For instance, many roadside invasive plants are shade intolerant; allowing neighboring vegetation to grow taller and provide shade can be an effective (and cheap) management strategy. Mowing of dikes and other areas, therefore, should be considered in light of this (see Appendix G).
2. Use chemical, mechanical, prescribed and natural fire (Nagel *et al.* 2008; Corace *et al.* 2008; DiAllesandro 2012) as means to manage infestations in cases where biological control techniques have not been developed.
3. Monitor the infestations and effectiveness of management measures.

Spatial (Unit/LTA) Focus: Most active management should occur in Units 1-3 (especially sites in the Seney Channel Fens and the Strangmoor Bog LTAs), with increasing emphasis on reducing extent of invasive species in Unit 1 and preventing establishment in Unit 2-3. Consider options for potential management in Unit 4 (Wilderness Area). This will also be the main management strategy for the Whitefish Point Unit. See Appendix G.

VI. Management Strategy Constraints and Impacts

A. Staffing and funding. The size of the refuge, the number of satellite refuges found in the complex (four, with multiple individual units), and the limited total number of staff (10, with 1 ecologist) preclude intensive/extensive inventorying and monitoring as is done on other Federal lands. It is critical the refuge prioritize research, management, inventorying, and monitoring as increases in staffing is unlikely. The refuge has been quite successful in the past in working with other cooperators to meet many of its needs and these partnerships should continue to be used to mitigate for staffing limitations. Funding for prescribed fire is also critical, as shown above by the acreages of habitats (ecosystems) that are fire-dependent at Seney NWR.

B. Invasive species. Seney NWR is part of two UP *Weed Cooperative Management Areas* and has been an active partner in invasive plant management for over a decade. Integrated pest (invasive plant) management at the refuge aims to reduce establishment, identify new species/populations, and use adaptive management technique to manage species in support of habitat objectives (see Appendix G). However, not all invasive species can be managed. For instance, European earthworms pose a threat to many forest ecosystems at the refuge and little can be done other than to mitigate for their impacts (Shartell 2012; Shartell *et al.* 2012). It is likely that other invasive species will pose a similar constraint on management in the future.

C. Climate change. Other than funding for staff and prescribed fire, climate change is perhaps the greatest single contemporary constraint on the proposed management of ecosystems and related habitats at Seney NWR (Griffith *et al.* 2009). Climate forcing has already been shown to have influenced past fire regimes (Drobyshev *et al.* 2012) and the distribution of small mammals (Myers *et al.* 2009) at the refuge. Climate change may affect the two major ecological processes that shape Seney, fire and hydrology. For instance, if snowfall and rainfall decline precipitously, management of refuge pools may be severely limited and fire seasonality changed. That said, climate change has occurred before and the concerns of potential impacts of climate change do not supersede other concerns at Seney, or it seems elsewhere (Magness *et al.* 2012). The most efficient way to deal with climate change at Seney NWR is to consider spatial patterns of native land cover types and the opportunities that exist in this publically owned matrix for natural shifts, emigration, and immigration of the distribution of species and ecosystems (the latter not dealt with here, but key to the entire issue). In other words, management should proceed under the assumption that systems with ecological integrity are better able to adapt to changes brought upon by shifting climate regimes (anthropogenic habitats, such as refuge pools, are therefore perhaps not sustainable). Unfortunately, most models on climate change are species-centric, and do not deal with multiple species, let alone ecosystems. Nonetheless, information from the USDA Forest Service's digital climate change atlas was used to infer possible changes to the flora and fauna of Seney NWR. The Forest Service has provided users with current suitable habitat distribution of trees and birds to be compared to future projections of habitat distributions. Using predictive importance variables derived for each species, a forest modeling program was run with results from three different climate models. All of which were projected to the end of the 21st century. The predictive importance variables were created from over 3 million records of species taken from the Forest Inventory and Analysis (FIA). Beside the three climate models, CO_2 scenarios were also varied to account for possible fluctuations that would arise should actions be taken to curb their emissions. In the interpretations that follow, information was taken from the unabated models with averaged results from the three different climate change models. Predictions for bird species incidence were orchestrated in a similar manner, but included data on temperatures, elevation, and vegetation preferred by the individual species. Tables 11-14 below contain predictive habitat changes for trees of Seney NWR and satellite refuges and incidence of IBA bird species at Seney NWR (few of these species were actually modeled, however). To better understand this interpretation, keep in mind that the importance value (IV) measurement is an estimation of suitable habitat in a 20 x 20 km^2 block and not the specific number of trees that will be found.

Table 11. Importance Value (IV) difference summary for tree species with decreasing habitat (ranked order) on Seney NWR or satellite refuges (*).

Species	Projection	IV Current	IV Change	Model Reliability
White spruce	decrease	1 to 3	-1 to -3	medium
Tamarack	decrease	1 to 3	-1 to -3	high
American beech	decrease	1 to 3	-1 to -3	high
Bigtooth aspen	decrease	1 to 3	-1 to -3	high
Yellow birch	decrease	1 to 3	-1 to -3	high
Eastern hemlock	decrease	1 to 3	-1 to -3	high
Paper birch	decrease	4 to 6	-3 to -6	high
Black ash	decrease	4 to 6	-3 to -6	high
Balsam poplar	decrease	1 to 3	-3 to -6	high
Red maple	decrease	11 to 20	-3 to -6	high
Red pine	decrease	4 to 6	- 4 to -6	medium
White pine	decrease	4 to 6	- 4 to -6	high
Trembling aspen	decrease	11 to 20	-6 to -10	high
Balsam fir	decrease	7 to 10	-6 to -10	high
Northern white cedar	decrease	7 to 10	-6 to -10	high
Black spruce	decrease	7 to 10	-6 to -10	high
Jack pine	decrease	7 to 10	-6 to -10	high
Sugar maple	decrease	11 to 20	-10 to -20	high

Table 12. Importance Value (IV) difference summary for tree species with increasing habitat (ranked order) on Seney NWR or satellite refuges (*).

Species	Projection	IV Current	IV Change	Model Reliability
White ash	increase	1 to 3	+1 to +3	high
Black cherry	increase	1 to 3	+1 to +3	high
American elm	increase	1 to 3	+1 to +3	medium
Hop-hornbeam	increase	1 to 3	+1 to +3	medium
Eastern cottonwood*	increase	0	+3 to +6	low
Northern red oak	increase	1 to 3	+3 to +6	high
White oak *	increase	0	+6 to +10	high

Table 13. Importance Value (IV) difference summary for tree species with uncertain change habitat on Seney NWR or satellite refuges (*).

Species	Projection	IV Current	IV Change	Model Reliability
American hornbeam	decrease or increase	0	-1 to +1	medium
Northern pin oak	decrease or increase	0	-1 to +1	medium
Pin cherry	decrease or increase	0	-1 to +1	medium
Green ash	decrease or increase	1 to 3	-1 to +1	medium

Table 14. Incidence difference summary for bird species with decreasing habitat on Seney NWR. Data for all other priority species did not exist.

Species	Projection	Incidence Current	Incidence Change	Model Reliability
Northern Harrier	decrease	.005 to .2	-.005 to -.2	low
Common Loon	decrease	0.2 to 0.4	-0.2 to -0.4	medium
American Bittern	decrease	0.2 to 0.4	-0.2 to -0.4	low

Before a full conclusion can be drawn it must be noted that significant lag times occur in tree species migrations and also many difficult to quantify variables such as biotic interaction, human disturbance, and natural disturbance have not been accounted for. With this in mind it can safely be said that in the future, with respect to current tree species on Seney NWR, there is strong evidence for a significant impact to species diversity. The shift appears to be away from the suitable habitat of the conifers and associated deciduous trees, toward deciduous trees that presently have little suitable habitat in this ecoregion. Bird species predictions, based on the same climate models, were less fruitful, however, since many birds of interest on the refuge were not analyzed by these models. Those that were listed however, showed similar results to many of the tree species with a perfect 1:1 ratio in reduction of incidence which parallels the nearly 1:1 ratio reduction observed for many of the tree species.

What will climate change do to the movement of white-tailed deer? Will they leave the refuge, for the most part, during the winter months and thereby reduce browse pressure? Or will they be around all year and increase the browse pressure? If the amount of snow that falls in the winter declines, will white-tailed deer still move south? How about pool management with less snow and rain? How about fire management with less snow and rain or more snow and rain and changes to evapotranspiration? Uncertainty exists and has always existed. This realization further supports a broad perspective to habitat (land-ecosystem) management at the refuge as a species by species approach is unrealistic and untenable.

D. Impacts to the resources of concern associated with the implementation of the proposed habitat management strategies. The current paradigm of conservation, restoration, and preservation across Units 1-4 (east to west) is far from perfect, but presents a realistic approach under the constraints in which the refuge operates. For instance, the conservation of altered landscape patterns in Unit 1 due to altered hydrology likely has already produced a novel ecosystem (Hobbs *et al.* 2009) that will likely not function within any NRV; cattail in the wetlands will continue to displace sedges and other plant species. Moreover, the altered hydrology that is associated with the conservation of these anthropogenic pools will likely further exacerbate invasive plant issues, as will the large number of vehicles that go through this unit during the 15 May – 15 October time period.

E. Management strategy prescriptions (timing, frequency, severity, etc.). Habitat management in many ways is the application of disturbance ecology principles. Disturbances regulate biomass, as do land managers. In other words, land managers are often purveyors of disturbances. The timing, frequency, scale, seasonality, severity, and intensity of disturbances are keys to managing ecological systems, as are considerations of recovery periods and biological legacies (Franklin 1993; Seymour and Hunter 1999). At Seney NWR, the attempt to apply natural disturbance patterns forms the basis of habitat management; restoration and preservation in Units 2-4 are especially dependent on natural disturbance regimes (Table 15, below). That said, prescriptions must be site specific and take into account the natural disturbance regime, past management activities, existing conditions, goals (conservation, restoration, preservation), and site-specific objectives (see Figure 11, below).

(1) Fire — Although our understanding of fire dynamics at Seney is incomplete, the works of Drobyshev *et al.* (2008a,b) and Drobyshev *et al.* (2012) have vastly improved our knowledge of the fire regime in the Seney vicinity for the past 300+ years. Data suggest that fire occurred at least once every 50-60 years prior to European settlement, with six large landscape-scale events occurring at a mean fire return interval (FRI) of approximately 37 years (removing the "Great Cutover" period of 1910, range: 27-73 years). Landscape-scale fire events occurred in 1754, 1791, 1864, 1891, 1910, and 1976 and were typically late-season events during which fire-dependent fuels in the wetland mosaic were connected by drought. However, smaller fires likely occurred more frequently, suggesting that return intervals prior to refuge establishment may have beeen closer to the FRI has differed from the pre-European patterns. In many areas it has been increased, while in some sites decreased. These changes are likely the result of less burnable vegetation on the refuge (due to more water being impounded in the anthropogenic pool system), prescribed fire limitations (e.g., smoke, etc.), and some management activities that were outside the NRV. Analyses also indicated that the majority of these historic fires were stand maintaining, surface fires with likely low severity in the pine-dominated ecosystems (not stand-replacing, crown fires). However, as the mosaic in which they occurred consist of both wetlands and uplands, it is possible that the overall regime had mixed-severity effects which differed between wetland and upland. Finally, data suggest that although landscape-scale fires were late-season, drought-driven events, fires have occurred whenever burnable fuels are found (approximately April thorugh October).

Future management should consider the following as guidelines for both the use of prescribed fire and mechanical treatments:

a. treatments in Units 2-4 should occur in the range of 25-77 year. However, in some sites in which fire has been excluded and where more shrubs and more mesic species (e.g., red maple, etc.) are invading sites and totaling limiting the accumulation of fine fuels (e.g., Unit 1), the fire return interval (FRI) may need to be shorter and the severity greater;
b. treatments should include dormant and growing season events as research has documented both occurred in pre-European times, with an emphasis on the latter;

c. treatments, in most instances, should not be stand-replacing in either wetland or upland ecosystems;
d. avoid any use of fire in "stump fields" or former mixed-pine sites that were logged and burned around the turn of the century. These areas are demarcated by scattered eastern white pine stumps and scattered jack pine. Burning in these sites will only reduce soil productivity which was drastically altered over 100 years ago. Also, take into consideration the effects of heavy fuel loads in prescribed fire in any other coniferous stands as this may affect both the overstory and the soils.

Table 15. Native vegetation habitat types at Seney NWR and disturbance regime characteristics (Frehlich 2002; Drobyshev *et al.* 2008a).

Habitat Type	Dominant Disturbance Agent	Other Disturbance Agent(s)	Common Disturbance Type	Historic Frequency	Typical Scale (10s, 100s, or 1,000s of acres)
Scrub-Shrub	Fire	Herbivory, hydrology	Surface fire-ground fire (mixed severity)	Mean 37 years (range: 27-73 years)	100s or 1000s
Open Wetlands	Fire	Herbivory, hydrology	Surface fire-ground fire (mixed severity)	Mean 37 years (range: 27-73 years)	100s or 1000s
Mixed Forest-Uplands	Fire	Herbivory, wind	Surface fire (mixed severity)	Mean 37 years (range: 27-73 years)	100s or 1000s
Coniferous Forest-Uplands	Fire	Herbivory, wind	Surface fire (mixed severity)	Mean 37 years (range: 27-73 years)	100s or 1000s
Mixed Forest-Lowlands	Wind	Fire, hydrology, herbivory	Individual tree, cohort	Yearly, decadal	<10, 100s (rarely)
Coniferous Forest-Lowlands	Wind	Fire, hydrology, herbivory	Individual tree, cohort (rarely)	Yearly, decadal	<10, 100s (rarely)
Deciduous Forest-Uplands	Wind	Herbivory, fire	Individual tree, cohort (rarely)	Yearly, decadal	<10
Deciduous Forest-Lowlands	Wind	Herbivory, hydrology, fire	Individual tree, cohort (rarely)	Yearly, decadal	<10

(2) Herbivory — Herbivory takes a number of different forms: browse by species such as white-tailed deer, American beaver foraging that is often linked to changes in hydrology, and the effects of insects and other potential plant defoliators. As such, herbivory can affect individuals or cohorts. For instances, white-tailed deer may limit understory recruitment of tree species that are preferred browse (e.g., oak, eastern hemlock, maple) and thereby affect individuals and an entire layer of a forest. Fortunately, so far browse (by itself) does not seem to be shaping ecosystems at Seney NWR, but may act in concert with other disturbances, such as non-native earthworms. Defoliating insects also do not seem to be a major issue (in most habitat types) and the community seems to be comprised of native defoliating species that work in concert with other disturbances. For instance, in jack pine-dominated forests jack pine budworm (*Choristoneura pinus pinus*) may increase fuel loads and increase severity of fires. Currently, no management is called for to limit herbivory at Seney NWR, although extending hunting opportunities and shooting antlerless deer is a justifiable proposition.

(3) Pathogens — In the deciduous forests-uplands, the non-native Beech Bark Disease Complex is causing single-tree mortality and cohort mortality of American beech trees and further promoting the most shade tolerant species, red and sugar maple, in the understory. Future management should increase canopy gap size so that gap-dependent species such as yellow birch may thrive, while looking for and promoting any resistant American beech that may exist (do NOT cut any American beech!). Understory planting of conifers such as eastern white pine, white spruce, and eastern hemlock may also help mitigate for the effects of the disease complex by minimizing overstory species diversity.

(4) Hydrology — The management of water at Seney NWR has a long history. Because waterfowl production was the initial goal of refuge management, considerable time was spent manipulating the hydrologic regime of the area through dikes, ditches, and pools. Fjetland (1973) investigated patterns of water management at the refuge and his results suggested that the intricate pattern of pool draw downs had relatively little impact on seasonal waterfowl production; regardless, the refuge continued with this management for decades thereafter. It is likely that Seney's geographic position, landscape structure, and soil conditions preclude the type of responses that managers wanted, namely production of dabbling species. Consequently, this document proposes that the approach to water management at Seney shift from the pools to the surrounding wetlands, American beaver ponds, and streams. Future water management in pools may be simplified for those species that utilize them for breeding (e.g., Osprey, Trumpeter Swan, Common Loon) and no data that we know of indicates that yearly or seasonally manipulating water levels leads to improved production of any of these species. Management should also consider pools for migrating waterfowl stopover habitat. Thus, we suggest that the pool levels be managed in a way that emulates more natural patterns: higher water levels in the spring and very gradual drawdown through the late summer, with recharging in the fall (in most instances, this can be done passively) (see Annual Water Plan).

Moreover, much more needs to be understood regarding the impacts of pool management on adjacent wetlands. Kowalski and Wilcox (2003) showed how dikes at the refuge have altered vegetation patterns above and below them. In general, shrub-scrub and coniferous forest-lowlands were displaced above the pool and replaced in the wetlands below as they were dried. These wetlands are now being "invaded" by these same scrub-shrub and coniferous forest (wetland) species; ultimately, open wetlands are the ecosystem type being most adversely impacted. More study is needed to understand the efficacy in producing more natural wetland patterns and the interaction between fire and hydrology at the refuge.

Figure 10. Severe wind event, Seney NWR (August 2011, photo April 2012).

(5) Wind — Like herbivory, wind can affect both individuals and cohorts. Severe thunderstorms can produce downbursts or microburst that can cause dramatic changes to vegetation. Such a case occurred at Seney in August 2011 in an aspen-dominated stand existing on partially drained, organic soils (Figure 10).

Based on the CCP, this area on the northern border of the refuge was to be harvested to maintain aspen on the site. However, staff decided to take advantage of this stochastic disturbance event and allow the system to develop as it now stands. It is expected that some aspen resprouting will occur, but that the canopy gaps caused by this disturbance will promote more complex composition and structure; conifers on site were seemingly not damaged in any way. If a similar event occurred on other lands in the eastern UP, salvage logging operations would likely have occurred. Thus, the patterns that develop are likely to be (at least locally) novel.

Emulating single tree or cohort effects of wind should be the basis of management in deciduous forests, especially those on more mesic soils. The larger the gap, the more shade-intolerant species are promoted and the more simplified the stand structure-age class (e.g., aspen management may look like Figure 10, with biological legacies). Conversely, in northern hardwood stands single-tree gaps created by individual trees with large crowns being blown over periodically promotes more diversified structure (retain much higher levels of residual structure) and age structure (Figure 11).

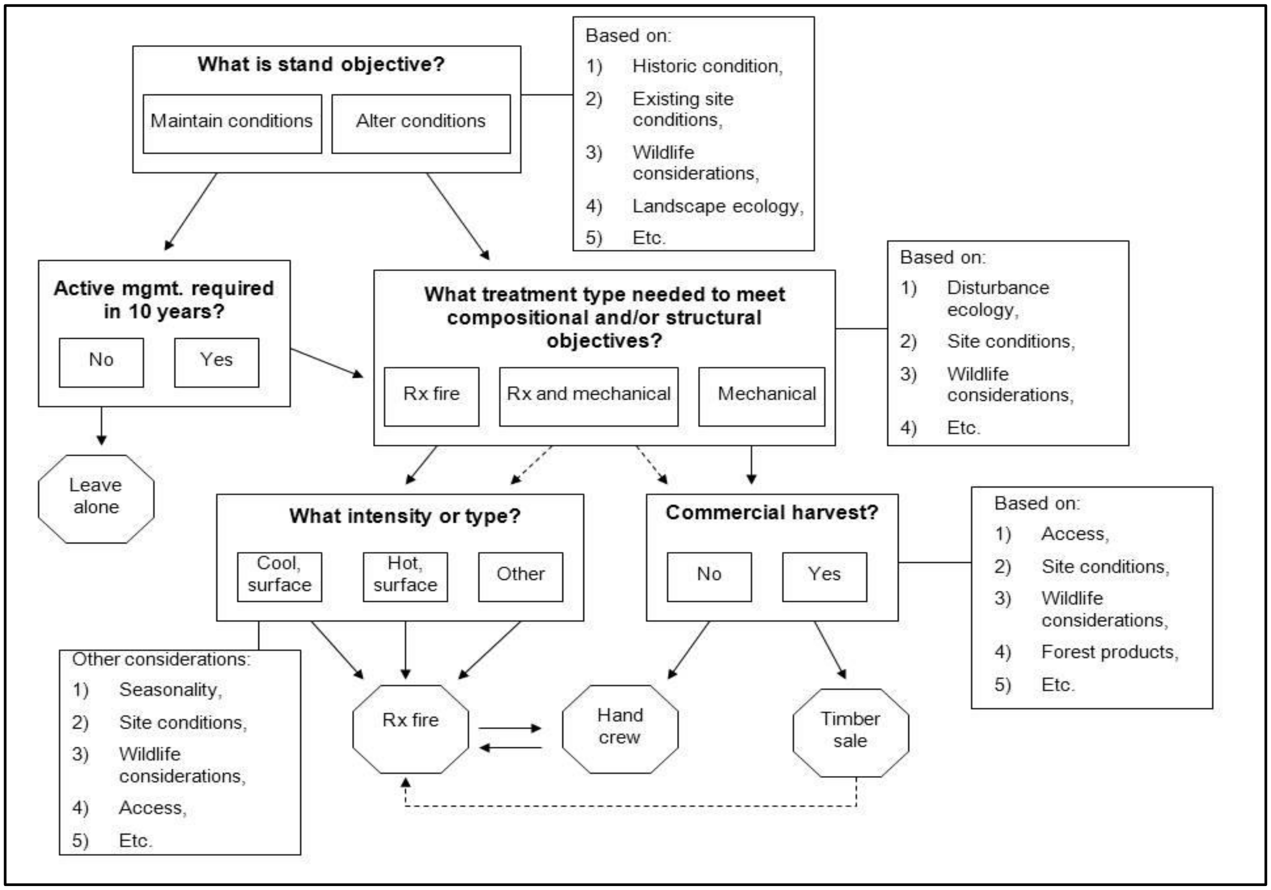


Figure 11. A conceptualized, and incomplete, silvicultural decision-making flow chart that is based, to a considerable degree, on the patterns of the natural disturbance agent associated with a given forest and site conditions. In the end, silviculture needs to be creative.

F. Management strategy documents.

(1) Necessary resources — The majority of the habitat (land-ecosystem) management discussed in this document (except prescribed fire!) can be achieved by existing refuge funds, but there are limitations imposed by the small staff size. For instance, other than prescribed fire, most forest management operations tend to pay for themselves, but to conduct more monitoring or assessments of forest stands is unlikely with existing staffing levels. Moreover, the refuge has many questions regarding hydrology and wetland restoration and management that require applied research or monitoring, but this is unlikely with current funding. However, a GS-7 or 9 Biological Technician could take lead on many of the monitoring activities and take lead on database development/integration.

(2) Documentation of special uses — Compatibility Determinations (CDs) that were done for the CCP (2009) included hunting, fishing, wildlife observation and photography, environmental education and interpretation, research, haying, and mushroom and berry picking. In most cases, haying will likely not be a major tool in the future as these fields succeed to forests. A Compatibility Determination (CD) for commercial timber harvesting (mechanical treatment of forests) was completed in 2010 and has been approved until 2023. No other CDs are expected to be necessary to achieve the actions listed above.

(3) Documentation of compliance — This document is a step-down to the Seney NWR CCP and its associated regulatory documents (e.g., NEPA).

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Appendices

Appendix A. Upland Old Fields and Openland Afforestation Plan

Management Considerations: The size, shape, and surrounding vegetation, as well as other uses for these fields, are important management considerations; in all old farm fields, the soil is basically the same. For instance, in smaller fields (such as Smith Farm) or narrower fields (such as Conlon Farm), wind-born seed from surrounding trees are likely to find their way into the field interior (some seed can move ~500'). Conversely, at Sub-Headquarters and Chicago Farm, the shape and size of these fields makes this less likely. Moreover, where aspen clones are found nearby, these can be treated (i.e., cut and left) as part of the management process so as to induce suckering into the fields and provide enhance composition and structure in the form of downed woody debris. Finally, the actual area to be treated at Sub-Headquarters is reduced due to a need to maintain conditions for the fire weather station. At Conlon Farm, the area for treatment is reduced due to a need for a helipad.

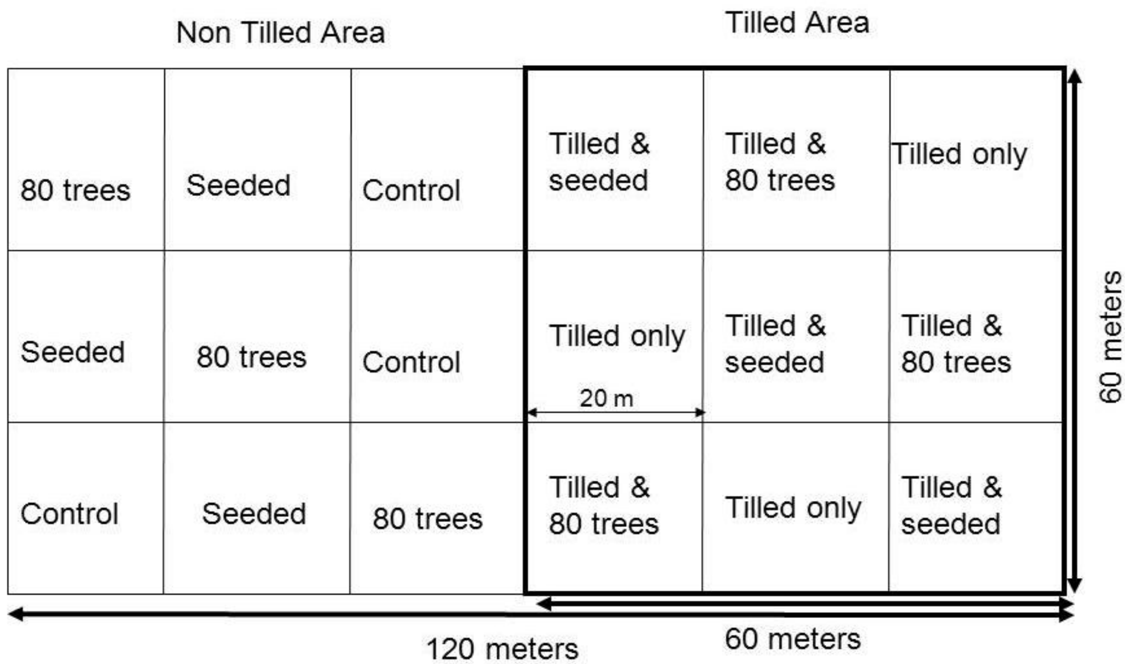
Management Options: Management options are based on a combination of ecological and economic factors. Regardless of option (or combination of options) chosen for a given field, considerable time will be required to allow for secondary succession to occur and the structure and composition of a forest ecosystem to develop. PATIENCE AND THE REMOVAL OF MAJOR DISTURBANCES ARE KEY! Overall, the greatest impediment to reversion to forests in these fields is the sod layer. Seeds from surrounding forests (which tend to fall, for most species, May-October) fall on the sod layer and desiccate before reaching mineral soil and germinating. Thus, in all cases, management of the sod layer is an important initial step. However, due to the potential environmental and economic cost, herbiciding these fields has not been considered a management option. Because prescribed fire would consume any viable tree seeds already in the fields, this management tool is not considered herein.

Table 1. Management options for different old fields at Seney NWR. This list is not exhaustive, but an overview of the main options, minus herbicide use.

Activity	Purpose	"Pros"	"Cons"	Suggested Fields	Year(s) of Work
Passive management	Allow the slow process of natural secondary succession to occur on its own, without active management of any kind	No cost, and a woodland or forest would develop over time; variable wildlife species use over time	Very slow, sod layer would slow forest succession; alternative steady states other than close-canopy forest possible; species such as American beech may not be present in future stand	Chicago	Starting ~2009
Management of sod layer in fields (May-July) followed by passive management	Stress and reduce the amount of sod by a combination of shallow plowing and disking and then allow natural secondary succession to occur	Low cost, and a woodland or forest would develop over time; variable wildlife species use over time	Slow; alternative steady states other than close-canopy forest possible; species such as American beech may not be present in future stand	Conlon, Smith, Sub-HQ	Done 2011/2
Management of sod (May-July) followed by seeding of native trees species adapted for the site (local genetic stock) at ~0,5-1 lb/ac (cut adjacent aspen)	Stress and reduce the amount of sod by a combination of shallow plowing and disking; enhance rate of forest development by seeding with native stock	Low cost; the rate at which a woodland or forest would develop over time increases	Cost of seed; mortality to seed due to desiccation, etc.; species such as American beech may not be present in future stand	None	-
Management of sod (May-July) followed by dormant season planting of native trees species adapted for the site (local genetic stock) at ~800 seedlings/ac then thin plantation after sod is killed	Stress and reduce the amount of sod by a combination of shallow plowing and disking; enhance rate of forest development by seeding with native stock that are part of seres (e.g., eastern white pine or other), ultimately promote natural seeding in	The rate at which a woodland or forest would develop over time increases	Cost of seedling, planting; mortality to seedlings due to browse/grubs, species such as American beech may not be present in future stand	None	-

and allow seeding in of neighboring trees (cut adjacent aspen)					
Management of sod (May-July) followed by combination of seeding and dormant season planting of ~800 seedlings/ac (field interior primarily) (cut adjacent aspen)	Stress and reduce the amount of sod by a combination of shallow plowing and disking; enhance rate of forest development by seeding with native stock that are part of seres (e.g., eastern white pine or other)	The rate at which a woodland or forest would develop over time increases	Cost of seedlings, cost of planting; species such as American beech may not be present in future stand	None	-
(Trans)planting (e.g., white or red pine) by summer staff, etc. during rainy weather	Establish forest cover on formerly mixed-pine sites by transplanting roadside stock or local red pine seedlings	Low cost; local genetic stock; the rate at which a woodland or forest would develop over time increases	Some mortality to transplanted stock	Driggs River Rd. opening	2011+

Monitoring and Assessment: During the 2011 season, we move forward with a combination of shallow plowing and disking both Conlon and Smith Fields. We will also set up a randomized block design (with replicates and controls) in both fields to monitor the effectiveness of other treatments (Fig. 1). At Conlon Farm (N46.21785,W85.96737; NAD83), the below monitoring design was placed facing NORTH (i.e., 80 seedlings (trees) were planted in the non-tilled area in the NORTHWEST corner). At Smith Farm (N46.23676,W85.95069; NAD83), the below was placed facing WEST (i.e., the 80 seedlings (trees) were planted in the non-tilled area in the SOUTHEAST corner). Rebar was used to demarcate plot corners.

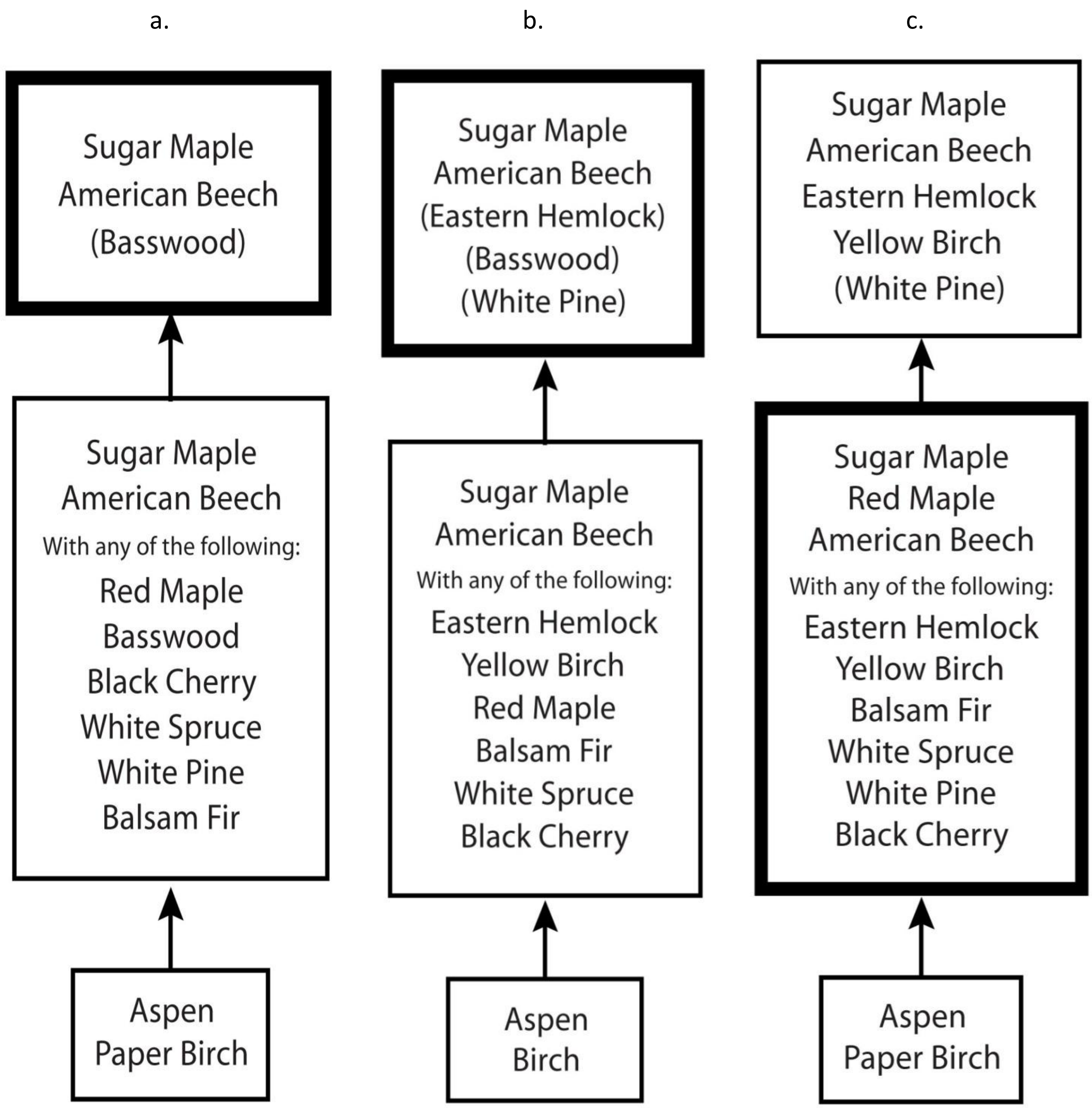


400 m^2 = 0.1 acre
Each site has 480 trees * 2 sites (Smith, Conlon) = 960 trees total

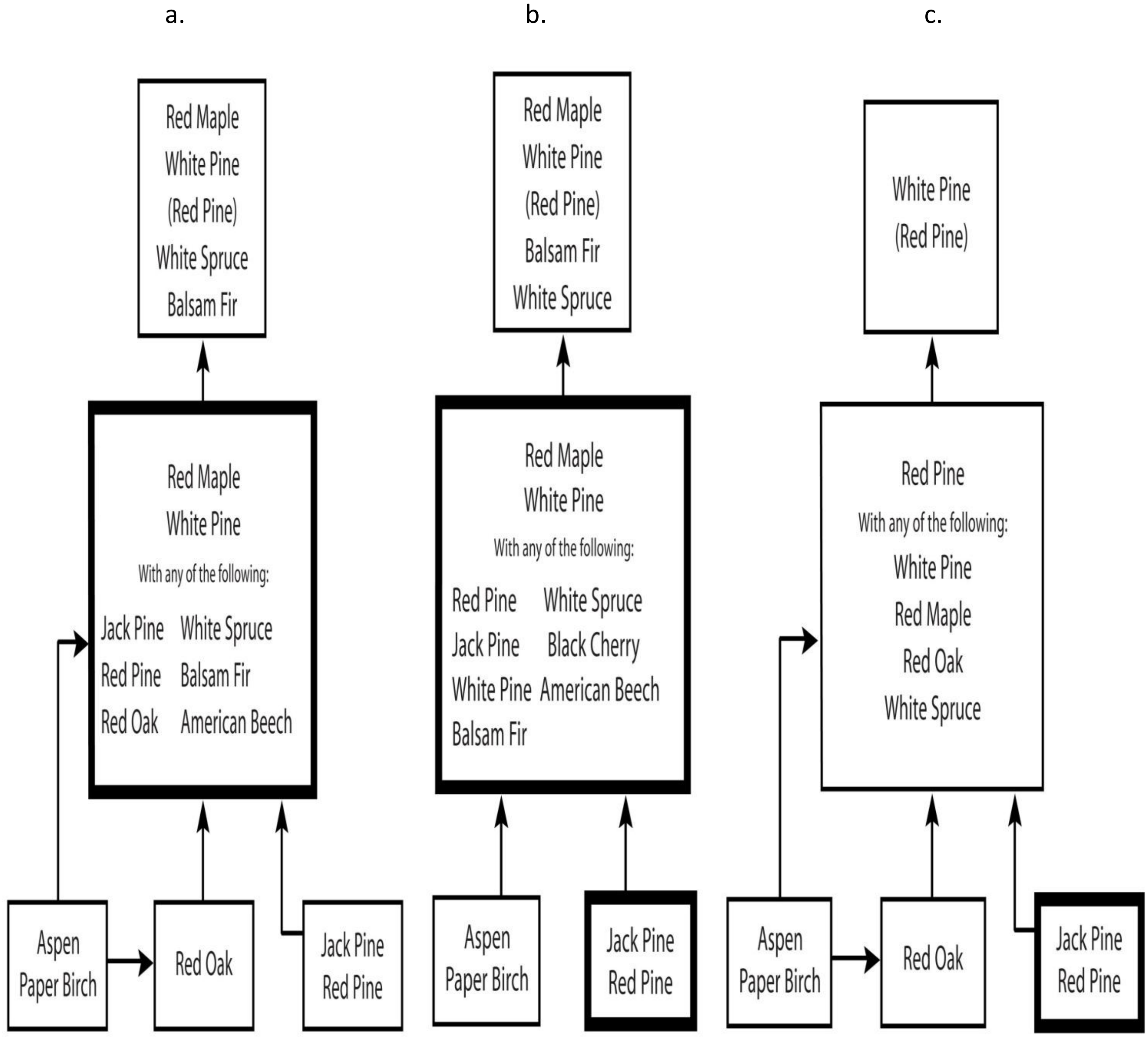
Appendix B. Soil Habitat Typing for Seney NWR

Habitat types (as provided by Burger and Kotar 2004) of upland soils of Seney NWR. These diagrams show probabilistic successional trajectories, but do not indicate the disturbance regime associated with the development of these seres. The overstory composition expected on these soils is also depicted.

a. AFOAs = Acer saccharum – Fagus grandifolia/Osmorhiza claytoni – Arisaema atrorubens
b. AFPo = Acer saccharum – Fagus grandifolia Polygonatum pubescens
c. ATFD = Acer saccharum –Tsuga canadensis –Fagus grandifolia/Dryopteris spinulosa



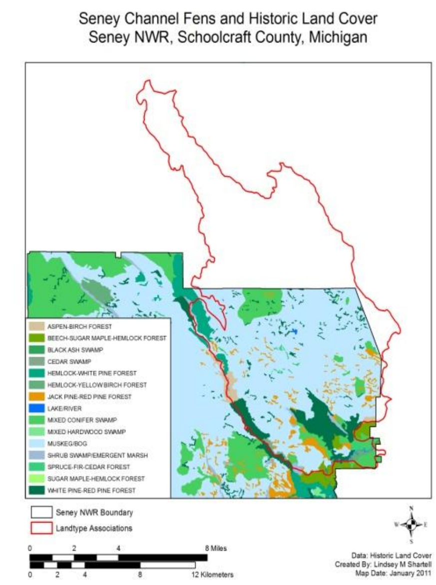
a. PArV = Pinus strobus – Acer rubrum/Vaccinium angustifolium
b. PArVAa = Pinus strobus – Acer rubrum/Vaccinium angustifolium-Aralia nudicaulis
c. PVE = Pinus strobus/Vaccinium angustifolium-Epigaea repens



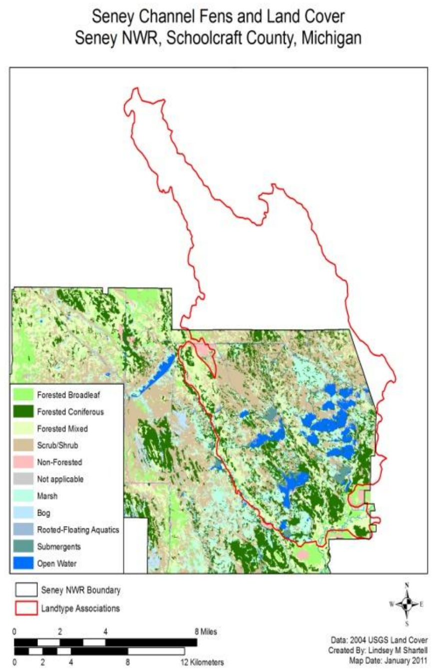
Appendix C. Land Type Association Assessment Data for Seney NWR

Assessment of historic and present-day land cover of Landtype Associations (LTAs) of Seney NWR. For some LTAs, present-day cover types <1% are not shown. Using the pre-European land cover layer of Comer *et al.* (1995) available from Michigan Natural Features Inventory (Michigan State University) and the Seney NWR's USGS land cover layer (derived from analysis of 2004 aerial imagery) we compared and contrasted "historic cover" and "present-day cover" within and among LTAs. Differences between the two time periods are largely the results of different scales of observation and assessment. See Figure 3, above, for the spatial relationships among LTAs at Seney NWR.

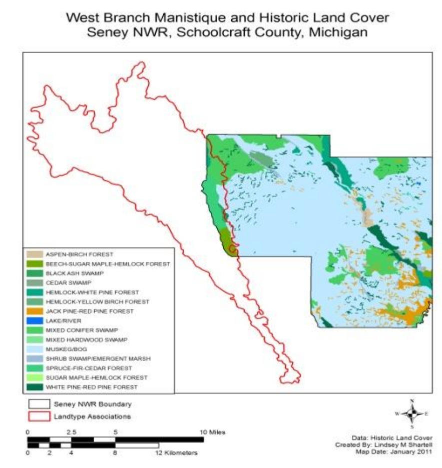
Hh05 Seney Channel Fens Historic Cover		
COVERTYPE	Acres	Percent(%)
MUSKEG/BOG	21,280.89	69.54
WHITE PINE-RED PINE FOREST	3,127.48	10.22
MIXED CONIFER SWAMP	2,606.15	8.52
JACK PINE-RED PINE FOREST	1,344.42	4.39
HEMLOCK-WHITE PINE FOREST	677.60	2.21
ASPEN-BIRCH FOREST	400.77	1.31
BEECH-SUGAR MAPLE-HEMLOCK FOREST	295.65	0.97
SPRUCE-FIR-CEDAR FOREST	268.35	0.88
SHRUB SWAMP/EMERGENT MARSH	244.01	0.80
HEMLOCK-YELLOW BIRCH FOREST	155.71	0.51
CEDAR SWAMP	107.49	0.35
LAKE/RIVER	93.11	0.30
Total	**30,601.64**	**100.00**



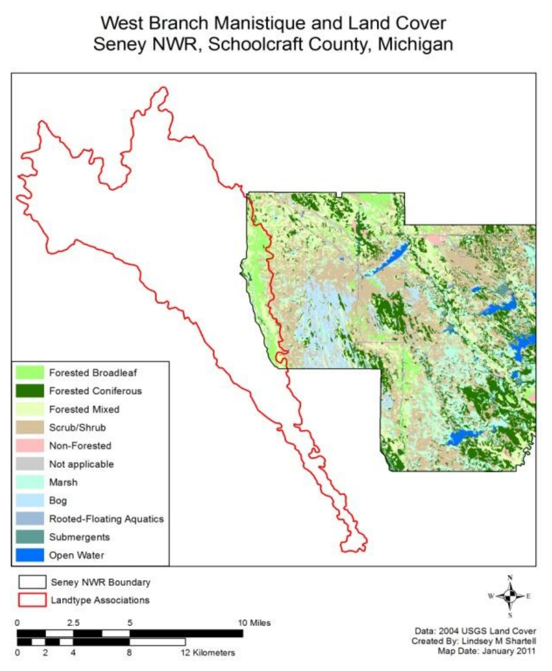
Hh05 Seney Channel Fens Present-Day Cover		
CODE_DESC	Acres	Percent(%)
Scrub/Shrub (Lowland)	9,082.81	29.68
Sedge/Bluejoint Grass	2,963.29	9.68
Water	2,730.61	8.92
Forested Broadleaf/Coniferous Mix (Lowland)	1,806.20	5.90
Forested Coniferous Mix (Upland)	1,624.89	5.31
Mixed Emergents/Grasses/Forbs	1,454.78	4.75
Forested Coniferous Mix (Lowland)	1,407.40	4.60
Forested Broadleaf/Coniferous Mix (Upland)	1,202.75	3.93
Aspen/Pine	1,197.37	3.91
Red Pine/Jack Pine	752.25	2.46
N. Hardwoods/White Pine/Hemlock	670.71	2.19
Tamarack/Spruce	614.95	2.01
Submergent Vegetation	570.19	1.86
Red Pine/White Pine	549.77	1.80
Jack Pine	491.58	1.61
Black Spruce	405.04	1.32
Aspen/Birch/Fir/Spruce (Lowland)	359.01	1.17
Cattail	310.16	1.01
Total	**28,193.76**	**92.10**



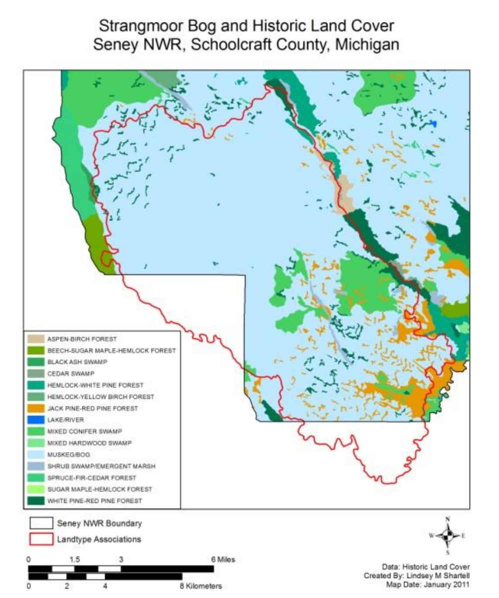
Hh06 West Branch Manistique Historic Cover		
COVERTYPE	Acres	Percent(%)
SPRUCE-FIR-CEDAR FOREST	1,462.26	36.28
MIXED CONIFER SWAMP	1,036.86	25.73
BEECH-SUGAR MAPLE-HEMLOCK FOREST	652.67	16.19
MUSKEG/BOG	603.29	14.97
HEMLOCK-WHITE PINE FOREST	139.17	3.45
BLACK ASH SWAMP	125.69	3.12
WHITE PINE-RED PINE FOREST	10.53	0.26
Total	**4,030.47**	**100.00**



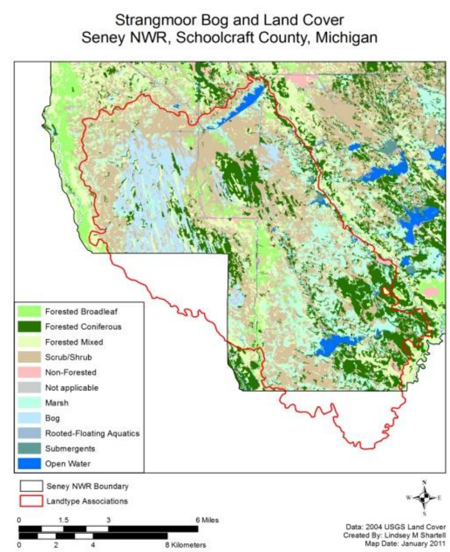
Hh06 West Branch Manistique Present-Day Cover		
CODE_DESC	Acres	Percent(%)
Northern Hardwoods (Maple/Beech/Yellow Birch)	544.52	13.54
Aspen/Pine	421.84	10.49
N. Hardwoods/White Pine/Hemlock	414.11	10.30
Forested Broadleaf/Coniferous Mix (Lowland)	389.19	9.68
Forested Broadleaf Mix (Upland)	378.52	9.41
Aspen (Upland)	371.91	9.25
Scrub/Shrub (Lowland)	322.34	8.01
Aspen (Lowland)	286.42	7.12
Forested Broadleaf/Coniferous Mix (Upland)	279.78	6.96
Forested Broadleaf Mix (Lowland)	125.13	3.11
Willow	104.71	2.60
Sedge/Bluejoint Grass	93.36	2.32
Aspen/Birch/Fir/Spruce (Lowland)	72.15	1.79
Water	44.49	1.11
Total	**3,848.48**	**95.69**



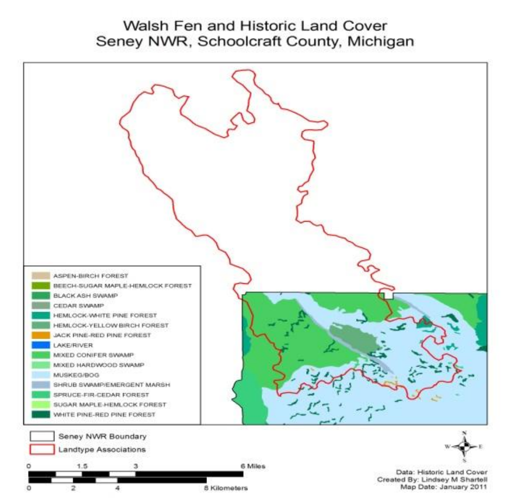
Hh07 Strangmoor Bog Historic Cover		
COVERTYPE	Acres	Percent(%)
MUSKEG/BOG	35,578.62	83.56
MIXED CONIFER SWAMP	2,833.92	6.66
JACK PINE-RED PINE FOREST	2,109.56	4.95
WHITE PINE-RED PINE FOREST	1,276.56	3.00
SHRUB SWAMP/EMERGENT MARSH	287.50	0.68
ASPEN-BIRCH FOREST	238.89	0.56
HEMLOCK-WHITE PINE FOREST	116.72	0.27
BEECH-SUGAR MAPLE-HEMLOCK FOREST	89.04	0.21
BLACK ASH SWAMP	40.19	0.09
SPRUCE-FIR-CEDAR FOREST	5.61	0.01
LAKE/RIVER	2.51	0.01
CEDAR SWAMP	0.98	0.00
Total	42,580.08	100.00



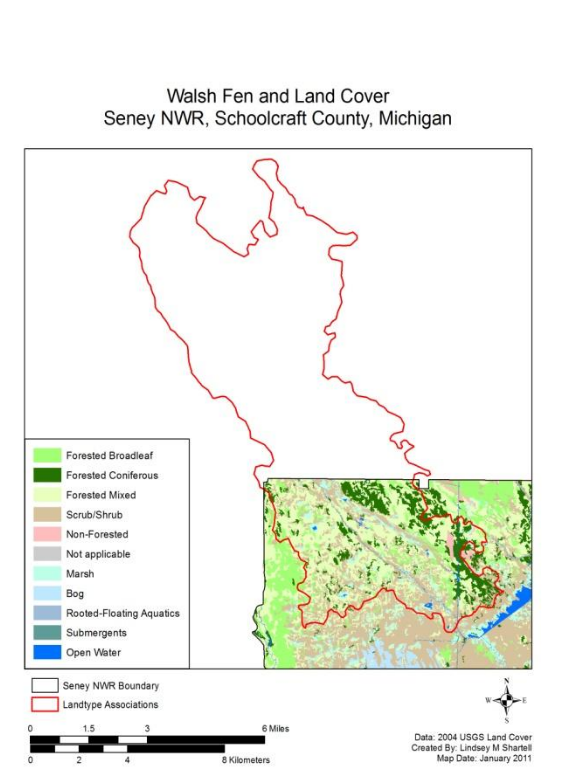
Hh07 Stangmoor Bog Present-Day Cover		
CODE_DESC	Acres	Percent(%)
Scrub/Shrub (Lowland)	13,766.18	32.34
Sedge/Bluejoint Grass	5,583.18	13.12
Sphagnum/Leatherleaf	4,149.58	9.75
Tamarack/Spruce	2,391.56	5.62
Forested Broadleaf/Coniferous Mix (Lowland)	1,830.65	4.30
Aspen/Pine	1,689.66	3.97
Mixed Emergents/Grasses/Forbs	1,418.49	3.33
Aspen/Birch/Fir/Spruce (Lowland)	1,384.45	3.25
Tag Alder	1,275.42	3.00
Water	872.59	2.05
Aspen (Upland)	780.59	1.83
Red Pine/Jack Pine	754.78	1.77
Forested Coniferous Mix (Lowland)	676.80	1.59
Forested Coniferous Mix (Upland)	672.51	1.58
Aspen (Lowland)	643.39	1.51
Black Spruce	628.71	1.48
Tamarack	616.67	1.45
Grass/Ferns	502.86	1.18
Forested Broadleaf/Coniferous Mix (Upland)	434.67	1.02
Willow	429.58	1.01
Jack Pine	424.73	1.00
Total	**40,927.06**	**49.02**



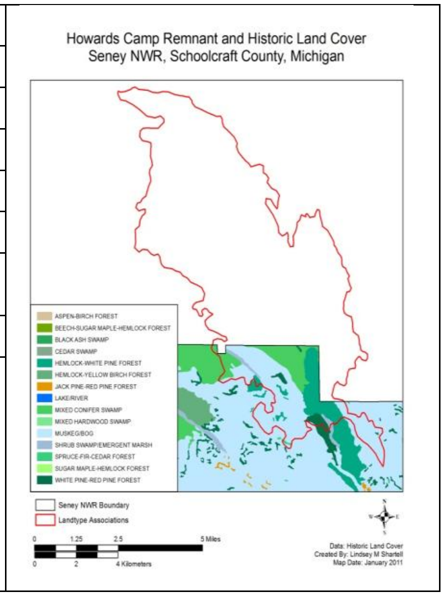
Hh08 Walsh Fen Historic Cover		
COVERTYPE	Acres	Percent(%)
MUSKEG/BOG	4,246.45	45.09
MIXED CONIFER SWAMP	3,868.11	41.07
HEMLOCK-YELLOW BIRCH FOREST	523.52	5.56
WHITE PINE-RED PINE FOREST	442.91	4.70
SHRUB SWAMP/EMERGENT MARSH	221.45	2.35
HEMLOCK-WHITE PINE FOREST	77.10	0.82
JACK PINE-RED PINE FOREST	32.98	0.35
SPRUCE-FIR-CEDAR FOREST	5.53	0.06
Total	**9,418.05**	**100.00**



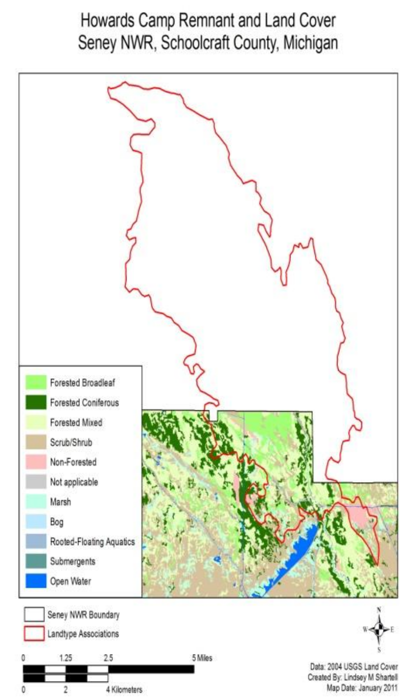
Hh08 Walsh Fen Present-Day Cover		
CODE_DESC	Acres	Percent(%)
Scrub/Shrub (Lowland)	2,505.63	26.60
Forested Broadleaf/Coniferous Mix (Lowland)	1,516.09	16.10
Aspen/Pine	1,412.49	15.00
Sedge/Bluejoint Grass	499.06	5.30
Forested Broadleaf/Coniferous Mix (Upland)	472.64	5.02
Forested Coniferous Mix (Upland)	455.58	4.84
Aspen (Lowland)	351.00	3.73
N. Hardwoods/White Pine/Hemlock	316.18	3.36
Red Pine	255.97	2.72
Forested Coniferous Mix (Lowland)	205.36	2.18
Aspen (Upland)	181.11	1.92
Aspen/Birch/Fir/Spruce (Lowland)	177.21	1.88
Red Pine/Jack Pine	156.48	1.66
Forested Broadleaf Mix (Lowland)	154.52	1.64
Hemlock (Upland)	150.71	1.60
Total	**8,810.05**	**48.33**



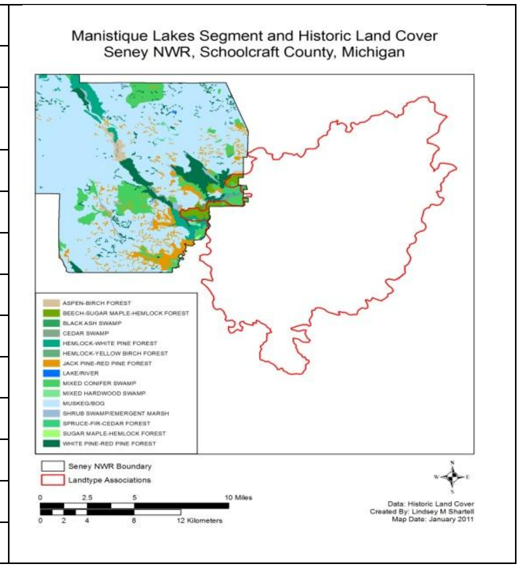
Hh09 Howards Camp Remnant Historic Cover		
COVERTYPE	Acres	Percent(%)
MUSKEG/BOG	2,215.83	55.92
MIXED CONIFER SWAMP	768.63	19.40
HEMLOCK-WHITE PINE FOREST	734.86	18.54
WHITE PINE-RED PINE FOREST	141.89	3.58
SHRUB SWAMP/EMERGENT MARSH	92.09	2.32
SPRUCE-FIR-CEDAR FOREST	9.49	0.24
Total	**3,962.79**	**100.00**



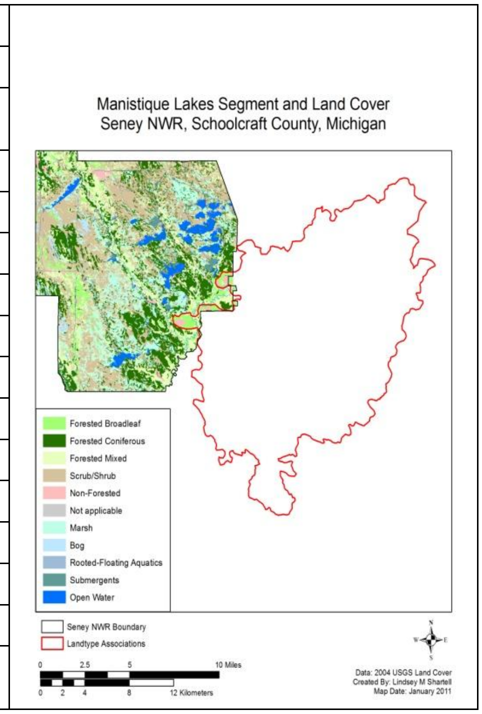
Hh09 Howards Camp Remnant Present-Day Cover		
CODE_DESC	Acres	Percent(%)
Scrub/Shrub (Lowland)	487.54	12.30
Aspen/Pine	470.75	11.88
Forested Broadleaf Mix (Lowland)	347.66	8.77
Forested Broadleaf/Coniferous Mix (Upland)	326.48	8.24
Forested Broadleaf/Coniferous Mix (Lowland)	294.87	7.44
Aspen (Lowland)	243.82	6.15
Forested Coniferous Mix (Upland)	189.81	4.79
Red Pine/Jack Pine	173.35	4.37
Grass/Ferns	170.44	4.30
Sedge/Bluejoint Grass	154.99	3.91
Aspen (Upland)	135.03	3.41
N. Hardwoods/White Pine/Hemlock	124.07	3.13
Hayfields	114.57	2.89
Aspen/Birch/Fir/Spruce (Lowland)	94.42	2.38
Red Pine	85.09	2.15
Willow	73.80	1.86
Forested Broadleaf Mix (Upland)	67.39	1.70
Northern Hardwoods (Maple/Beech/Yellow Birch)	59.08	1.49
Developed	55.02	1.39
Tag Alder	49.70	1.25
Forested Coniferous Mix (Lowland)	44.84	1.13
Water	44.10	1.11
Total	**3,806.03**	**96.06**



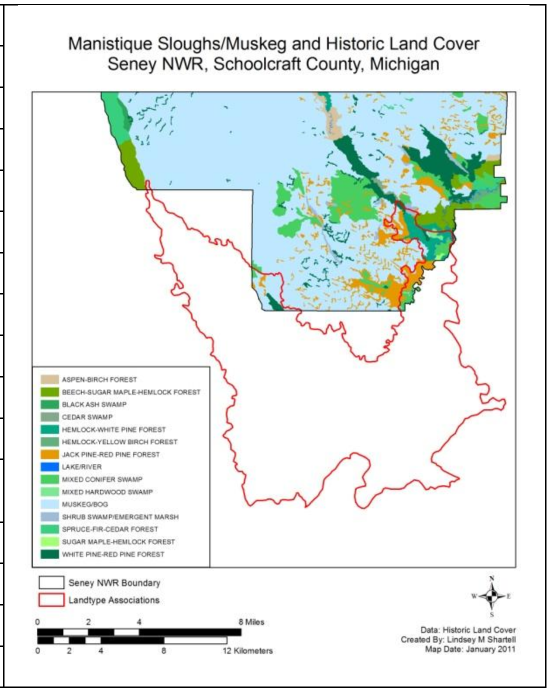
Hj22 Manistique Lakes Segment Historic Cover		
COVERTYPE	Acres	Percent(%)
BEECH-SUGAR MAPLE-HEMLOCK FOREST	888.17	65.86
MIXED CONIFER SWAMP	169.50	12.57
HEMLOCK-WHITE PINE FOREST	147.01	10.90
WHITE PINE-RED PINE FOREST	43.69	3.24
SPRUCE-FIR-CEDAR FOREST	29.15	2.16
LAKE/RIVER	25.72	1.91
MIXED HARDWOOD SWAMP	15.64	1.16
ASPEN-BIRCH FOREST	12.10	0.90
HEMLOCK-YELLOW BIRCH FOREST	11.58	0.86
MUSKEG/BOG	6.09	0.45
Total	**1,348.65**	**100.00**



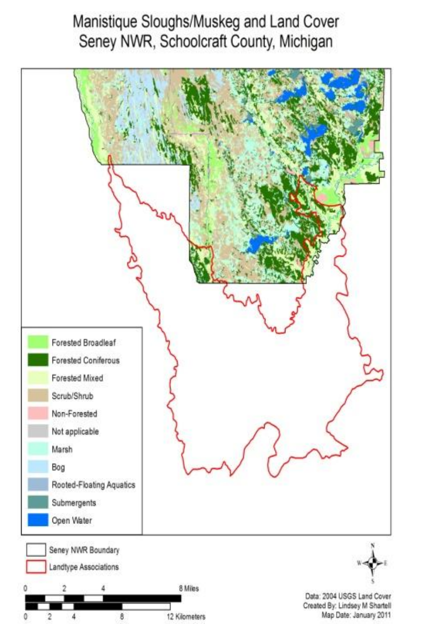
Hj22 Manistique Lakes Segment Present-Day Cover		
CODE_DESC	Acres	Percent(%)
Northern Hardwoods (Maple/Beech/Yellow Birch)	550.45	40.98
Hayfields	221.63	16.50
Forested Broadleaf/Coniferous Mix (Upland)	128.47	9.56
Aspen (Upland)	74.47	5.54
Developed	48.77	3.63
Aspen/Pine	46.95	3.50
N. Hardwoods/White Pine/Hemlock	46.34	3.45
Scrub/Shrub (Lowland)	42.38	3.16
Forested Broadleaf Mix (Upland)	37.93	2.82
Aspen/Birch/Fir/Spruce (Lowland)	26.76	1.99
Water	25.52	1.90
Forested Coniferous Mix (Upland)	19.58	1.46
Forested Broadleaf/Coniferous Mix (Lowland)	14.29	1.06
Total	**1,283.54**	**95.56**



Hh23 Manistique Sloughs/Muskeg Historic Cover		
COVERTYPE	Acres	Percent(%)
MUSKEG/BOG	1,055.08	30.94
JACK PINE-RED PINE FOREST	772.17	22.64
HEMLOCK-WHITE PINE FOREST	688.96	20.20
MIXED CONIFER SWAMP	405.64	11.90
WHITE PINE-RED PINE FOREST	221.27	6.49
MIXED HARDWOOD SWAMP	71.59	2.10
LAKE/RIVER	64.83	1.90
SHRUB SWAMP/EMERGENT MARSH	43.95	1.29
SUGAR MAPLE-HEMLOCK FOREST	39.02	1.14
BEECH-SUGAR MAPLE-HEMLOCK FOREST	20.56	0.60
SPRUCE-FIR-CEDAR FOREST	15.85	0.46
ASPEN-BIRCH FOREST	9.96	0.29
CEDAR SWAMP	1.01	0.03
Total	**3,409.88**	**100.00**



Hh23 Manistique Sloughs/Muskeg Present-Day Cover		
CODE_DESC	Acres	Percent(%)
Aspen/Pine	602.84	17.74
Forested Broadleaf/Coniferous Mix (Upland)	252.67	7.43
Forested Coniferous Mix (Upland)	244.74	7.20
Red Pine/Jack Pine	244.43	7.19
N. Hardwoods/White Pine/Hemlock	214.28	6.30
Northern Hardwoods (Maple/Beech/Yellow Birch)	202.35	5.95
Aspen/Birch/Fir/Spruce (Lowland)	190.86	5.62
Spruce/Fir	170.38	5.01
Aspen/Birch/Fir/Spruce (Upland)	150.13	4.42
Scrub/Shrub (Lowland)	138.12	4.06
Water	120.11	3.53
Aspen (Upland)	119.68	3.52
Jack Pine	110.92	3.26
Tamarack/Spruce	108.55	3.19
Black Spruce	85.45	2.51
Sedge/Bluejoint Grass	82.55	2.43
Forested Broadleaf/Coniferous Mix (Lowland)	61.65	1.81
Aspen (Lowland)	60.79	1.79
Red Pine	58.72	1.73
Forested Coniferous Mix (Lowland)	37.40	1.10
Total	**3,256.52**	**95.82**



Appendix D. Resources of Concern Listed in CCP (List has been reduced substantially for HMP)

Occurrence on the refuge: a= abundant; c=common; u=uncommon; r=rare, occasional, vagrant

Common Name	Scientific Name	Special Designations			Occurrence on the Refuge				Preferred Habitat(s)
		USFWS Midwest Conservation Priority	*USFS Regional Forester Sensitive*	*MDNR Michigan Special Animal*	a	c	u	r	
Birds									
Common Loon	*Gavia immer*	√	√	√		√			*OWA*
Double-creasted Comorant	*Phalacrocorax auritus*	√						√	*OWA*
American Bittern	*Botaurus lentiginosus*	√		√		√			*OWE*
Least Bittern	*Ixobrychus exilis*	√	√	√				√	*OWE*
Black-crowned Night Horn	*Nycticorax nycticorax*	√	√	√				√	*OWE*
Trumpeter Swan	*Cygnus buccinator*	√	√	√	√				*OWA*
Snow Goose	*Chen caerulescens*	√						√	*OWA*
Canada Goose	*Branta canadensis*	√			√				*OWA*
American Black Duck	*Anas rubripes*	√				√			*OWA*
Canvasback	*Aythya valisineria*	√						√	*OWA*
Lesser Scaup	*Aythya affinis*	√						√	*OWA*
Wood Duck	*Aix Sponsa*	√				√			*OWA, OWE*
Mallard	*Anas platyrhynchos*	√				√			*OWA, OWE*
Blue-winged Teal	*Anas discors*	√				√			*OWA, OWE*
Northern Pintail	*Anas acuta*	√						√	*OWA, OWE*
Osprey	*Pandion haliaetus*			√		√			*OWA*
Bald Eagle	*Hailiaeetus leucocephalus*	√		√		√			*OWA*

Peregrine Falcon	*Falco peregrinus*	√	√	√				√	*OWE, GRA, HAY*
Merlin	*Falco columbarius*			√			√		*DCF, DMF, MCF, MMF, WCF, WMF*
Red-shouldered Hawk	*Buteo lineatus*	√	√	√				√	*WMF, WCF*
Cooper's Hawk	*Accipiter cooperii*			√			√		*DCF, DMF, MCF, MMF, WCF, WMF*
Northern Goshawk	*Accipiter gentiles*	√	√	√			√		*DCF, DMF, MCF, MMF, WCF, WMF*
Northern Harrier	*Circus cyaneus*	√	√	√		√			*OWE, GRA, HAY, OLD*
Spruce Grouse	*Falcpennis canadensis*		√	√			√		*DCF, WCF*
Sharp-tailed Grouse	*Tympanuchus phasianellus*		√	√			√		*GRA, HAY, OLD*
Yellow Rail	*Coturnicops noveboracensis*	√	√	√			√		*OWE*
Upland Sandpiper	*Bartramia longicauda*	√	√				√		*GRA, HAY, OLD*
American Woodcock	*Scolopax minor*	√				√			*SUP*
Greater Yellowlegs	*Tringa melanoleuca*	√				√			*SHO*
Caspian Tern	*Sterna caspia*		√	√		√			*OWA*
Common Tern	*Sterna hirundo*	√	√	√			√		*OWA*
Black Tern	*Chlidonias niger*	√	√	√			√		*OWA, OWE*
Black-billed Cuckoo	*Coccyzus erythropthalmus*	√					√		*SWE, SUP*
Long-eared Owl	*Asio otus*	√		√			√		*DCF, DMF, WCF, WMF*

Great Gray Owl	*Strix nebulosa*		√					√	*OWE, GRA, HAY, OLD*
Short-eared Owl	*Asio flammeus*		√	√				√	*OWE, GRA, HAY, OLD*
Boreal Owl	*Aegolius funereus*		√					√	*WDF*
Whip-poor-will	*Troglodytes aedon*	√					√		*DCF, GRA, HAY, OLD*
Black-backed Woodpecker	*Picoides arcticus*		√	√			√		*DCF, DMF, MCF, MMF, WCF, WMF*
Northern Flicker	*Colaptes auratus*	√			√				*DCF, DMF, MCF, MMF, WCF, WMF*
Red-headed Woodpecker	*Melanerpes erythrocephalus*	√						√	*GRA, HAY, OLD*
Olive-sided Flycatcher	*Contopus cooperi*	√	√				√		*DCF, DMF, MCF, MMF, WCF, WMF*
Yellow-bellied Flycatcher	*Empidonax flaviventris*		√			√			*DCF, DMF, MCF, MMF, WCF, WMF*
Marsh Wren	*Cistothorus palustris*			√			√		*OWE, SWE*
Sedge Wren	*Cistothorus platensis*	√				√			*SWE*
Wood Thrush	*Hylocichla mustelina*	√					√		*MMF, DCF*
Swainson's Thrush	*Catharus ustulatus*		√				√		*WCF, WMF*
Black-throated Blue Warbler	*Dendroica caerulescens*	√	√				√		*MDF*

Canada Warbler	*Wilsonia canadensis*	√					√		*MDF, WMF, MMF*
Kirtland's Warbler	*Dendroica kirtlandii*	√		√				√	*DCF*
Connecticut Warbler	*Oporornis agilis*	√	√			√			*SUP*
Cape May Warbler	*Dendroica tigrina*	√					√		*WCF, WMF*
Bay-breasted Warbler	*Dendroica castanea*		√				√		*WCF, WMF*
Cerulean Warbler	*Denroica cerulean*	√	√	√				√	*WMF, WCF*
Gold-winged Warbler	*Vermivora chrysoptera*	√						√	*SUP*
Field Sparrow	*Spizella pusilla*						√		*GRA, HAY, OLD, SUP*
Le Conte's Sparrow	*Ammodramus leconteii*	√	√			√			*OWE*
Bobolink	*Dolichonyx oryzivorus*	√	√			√			*GRA, HAY, OLD, PAS*
Eastern Meadowlark	*Sturnella magna*	√					√		*GRA, HAY, OLD, PAS*
Western Meadowlark	*Sturnella neglecta*	√		√				√	*GRA, HAY, OLD, PAS*
Mammals									
Water Shrew	*Sorex palustris*		√				√		*MDF, MMF, MCF, SHO*
Northern Bat	*Myotis septentrionalis*		√					√	*DDF*
Gray Wolf	*Canis lupus*	√		√			√		*DDF, MDF, DMF, MMF, DCF, MCF, SUP, OLD, GRA, PAS, HAY, SHO*

Black Bear	*Ursus americanus*		√			√			*DDF, MDF, DMF, MMF, DCF, MCF*
River Otter	*Lutra canadensis*		√			√			*OWA*
Badger	*Taxidae taxus*		√					√	*GRA, PAS, HAY*
Marten	*Martes americana*		√				√		*DCF, MCF*
Canada Lynx	*Lynx canadensis*			√				√	*DCF, MCF, WCF*
Bobcat	*Lynx rufus*		√			√			*DMF, MMF, DCF, MCF*
Moose	*Alces alces*			√			√		*WCF, SWE*
Fish									
Brook Trout	*Salvelinus fontinalis*	√						√	*OWA*
Pugnose Shiner	*Notropis anogenus*			√				√	*OWA*
Sea Lamprey	*Petromyzon marinus*	√						√	*OWA*
Lake Sturgeon	*Acipenser fulvescens*	√		√				√	*OWA*
Herpofauna									
Wood Turtle	*Clemmys insculpta*		√	√			√		*WCF, SHO, SWE*
Blanding's Turtle	*Emydoidea blandingii*		√	√				√	*WCF, SWE, SHO, GRA, OLD, OWE*
Chorus Frog	*Pseudacris triseriata*			√			√		*WDF, MDF, GRA, OWE*
Four-toed Salamander	*Hemidactylium scutatum*		√					√	*WCF, OWE*

[a]Habitat definitions (Brewer et al. 1991): **DDF**= Dry Deciduous Forest of Savanna; **MDF**= Mesic Deciduous Forest; **WDF**= Wet Deciduous Forest; **DMF**= Dry Mixed Forest or Savanna; **MMF**= Mesic Mixed Forest; **WMF**= Wet Mixed Forest; **DCF**= Dry Coniferous Forest; **MCF**= Mesic Coniferous Forest; **WCF**= Wet Coniferous Forest; **SUP**= Shrub Uplands; **SWE**= Shrub Wetland; **OLD**= Old Field; **GRA**= Grassland; **PAS**= Pasture; **HAY**= Hayfield; **OWE**= Open Wetland; **SHO**= Shoreland; **OWA**= Open Water

Appendix E. Species Listed in this Document

Common Name	Scientific Name
Plants	
American Basswood	*Tilia americana*
American Beech	*Fagus grandifolia*
American Elm	*Ulmus americana*
American Hornbeam	*Carpinus caroliniana*
Balsam Fir	*Abies balsamea*
Balsam Poplar	*Populus balsamifera*
Bigtooth Aspen	*Populus grandidentata*
Black Ash	*Fraxinus nigra*
Black Cherry	*Prunus serotina*
Black Spruce	*Picea mariana*
Eastern Cottonwood	*Populus deltoides*
Eastern Hemlock	*Tsuga canadensis*
Eastern White Pine	*Pinus strobus*
Glossy Buckthorn	*Frangula alnus*
Green Ash	*Fraxinus pennsylvanica*
Jack Pine	*Pinus banksiana*
Kentucky Bluegrass	*Poa pratensis*
Multiflora Rose	*Rosa multiflora*
Northern Pin Oak	*Quercus ellipsoidalis*
Northern Red Oak	*Quercus rubra*
Northern White Cedar	*Thuja occidentalis*
Oregon Ash	*Fraxinus latifolia*
Paper Birch	*Betula papyrifera*
Pin Cherry	*Prunus pensylvanica*
Red Maple	*Acer rubrum*
Red Pine	*Pinus resinosa*
Sugar Maple	*Acer saccharum*
Tamarack	*Larix laricina*

Tatarian Honeysuckle	*Lonicera tatarica*
Trembling Aspen	*Populus tremuloides*
White Ash	*Fraxinus americana*
White Oak	*Quercus alba*
White Spruce	*Picea glauca*
Yellow Birch	*Betula alleghaniensis*
Birds	
American Bittern	*Botaurus lentiginosus*
Black-backed Woodpecker	*Picoides arcticus*
Black Scoter	*Melanitta americana*
Canada Goose	*Branta canadensis*
Caspian Tern	*Hydroprogne caspia*
Common Loon	*Gavia immer*
Common Tern	*Sterna hirundo*
Golden Eagle	*Aquila chrysaetos*
Le Conte's Sparrow	*Ammodramus leconteii*
Mallard Duck	*Anas platyrhynchos*
Merlin	*Falco columbarius*
Northern Harrier	*Circus cyaneus*
Olive-sided Flycatcher	*Contopus cooperi*
Osprey	*Pandion haliaetus*
Peregrine Falcon	*Falco peregrinus*
Sedge Wren	*Cistothorus platensis*
Sharp-tailed Grouse	*Tympanuchus phasianellus*
Spruce Grouse	*Falcipennis canadensis*
Trumpeter Swan	*Cygnus buccinator*
Whip-poor-will	*Caprimulgus vociferous*
Wood Duck	*Aix sponsa*
Yellow Rail	*Coturnicops noveboracensis*
Other Animals	

American Beaver	*Castor canadensis*
Gray Wolf	*Canis lupus*
Jack Pine Budworm	*Choristoneura pinus*
Mink Frog	*Rana septentrionalis*
White-tailed Deer	*Odocoileus virginianus*
Wood Turtle	*Glyptemys insculpta*

Appendix F. Lumping of 42[a] USGS Land Covers to Produce 10 Habitat Types

Habitat Type	USGS Land Covers Lumped
Scrub-Shrub	Scrub/Shrub (Lowland), Tag Alder, Willow, Scrub/Shrub (Upland)
Open Wetlands	Sedge/Bluejoint Grass, Mixed Emergents/Grasses/Forbs, Cattail, Sphagnum/Leatherleaf
Mixed Forest-Uplands	Aspen/Pine, Forested Broadleaf/Coniferous Mix (Upland), N. Hardwoods/White Pine/Hemlock, Aspen/Birch/Fir/Spruce (Upland)
Coniferous Forest-Uplands	Forested Coniferous Mix (Upland), Red Pine/Jack Pine, Jack Pine, Red Pine/White Pine, Red Pine, Spruce/Fir, Hemlock (Upland), White Pine, Northern White Cedar (Upland)
Mixed Forest-Lowlands	Forested Broadleaf/Coniferous Mix (Lowland), Aspen/Birch/Fir/Spruce (Lowland)
Coniferous Forest-Lowlands	Tamarack/Spruce, Forested Coniferous Mix (Lowland), Black Spruce, Tamarack, Northern White Cedar (Lowland), Hemlock (Lowland)
Open Water	Water, Rooted-Floating Vegetation, Submergent Vegetation
Deciduous Forest-Uplands	Aspen (Upland), Northern Hardwoods (Maple/Beech/Yellow Birch), Forested Broadleaf Mix (Upland)
Deciduous Forest-Lowlands	Aspen (Lowland), Forested Broadleaf Mix (Lowland), Hardwoods (Lowland)
Upland Old Fields and Openland	Grass/Ferns, Hayfields

[a]Developed land not included.

Appendix G. Integrated Pest Management Plan

Background

Invasive species threaten ecosystems worldwide because of their ability to alter natural communities, patterns, and processes. Many invasive species are non-native (also referred to as exotic, non-indigenous, or alien species) and have been introduced by humans or in association with human activities. At Seney NWR, many non-native plants and pathogens have been identified, and many more occur in the eastern Upper Peninsula. These species present a future threat of colonization at Seney NWR.

In a recent survey of NWR managers and biologists, the majority agreed that invasive species were among the most important drivers of landscape change (Magness *et al.* 2012). Management should therefore strive to assess the threat invasive species have on native ecosystems and habitat structure and function and (for those species that constitute the greatest threats) an active management and monitoring program should ensue. Efficient and effective management of invasive species requires an integrated (adaptive management) approach including: 1) threat evaluation, 2) prevention, 3) treatment, and 4) evaluation and monitoring. The following *Integrated Pest Management Plan* (IPMP) provides guidance for the management of invasive species at Seney NWR, with the goal of conserving and restoring native communities for the benefit of native wildlife species and their habitats and the public that enjoys them. The Seney NWR *Comprehensive Conservation Plan* (CCP, 2009) and *Habitat Management Plan* (HMP, 2013) laid out the background, land management goals and objectives, and assessment of historical and current conditions. This plans builds on the strategies in the HMP for invasive species (see the HMP for more background).

Species of Concern

Numerous invasive species are known to be currently present at Seney NWR (Table 1). In addition, many species occur in the surrounding landscape that present a potential threat for invasion and should be targets for prevention and detection (*e.g.*, garlic mustard). Communication with conservation partners (including two Cooperative Weed Management Areas) should continue so as to inform management decisions. Nonetheless, management priority is based on current and potential threats to native ecosystems; many non-native plants at Seney NWR are roadside species that do not threaten native ecosystems and pose relatively little threat of becoming invasive. **Of high priority for management at Seney NWR are glossy buckthorn, reed canary grass, purple loosestrife (not known to be currently present at Seney, but is on a Kirtland's Warbler WMA tract in nw Clare Co.), leafy spurge, garlic mustard (not known to be currently present), multiflora rose, Tartarian honesuckle, non-native common reed or phragmites, forget-me-not, and beech bark disease complex. Priority for management at the Whitefish Point Unit of Seney NWR is spotted knapweed.**

Table 1. Known non-native plant and animal species of concern, management priority, and current status at Seney NWR. For a list of other species found in the eastern Upper Peninsula, the user should contact colleagues in the Central and Eastern Upper Peninsula Cooperative Weed Management Areas.

Taxon/Species	Priority	Status
Plants		
Glossy buckthorn	High	Widespread in Unit 1; scattered in Unit 2-3; management priority since 2003 with numerous successes/lessons learned; research has shown efficacy of treatments using 2.5% a.i. *Rodeo*
Reed canary grass	High	One main patch in Unit 1; no past management activities known
Purple loosestrife	High	Absent?; has shown up periodically in Unit 1 and has been extirpated using 2.5% a.i. *Rodeo*, status elsewhere not known, but populations are found off Manistique River Rd. to the south and on South Manistique Lake. Also a Kirtland's Warbler WMA parcel in Clare Co. has been managed for this species: T20N-R5W S. 5 SE1/4
Leafy spurge	High	Sporadic populations in Units 1 and 2; sporadic management in the past using 2.5% a.i. *Rodeo*
Garlic mustard	High	Absent?
Non-native phragmites	High	Samples taken from Units 1-3 only show some small non-native patches in Unit 1; sporadic management in the past using 2.5% a.i. *Rodeo* has extirpated this phenotype?
Multiflora rose	Medium	Sporadic populations in Units 1-3; sporadic management using 2.5% a.i. *Rodeo* in the past with some success; plants do not seem to be thriving
Spotted knapweed	Medium	Widespread throughout Unit 1-3 wherever roads exists and at Diversion Farm; does not thrive anywhere where it needs to compete for sunlight (e.g., in dense vegetation, in forests); primary management is to allow surrounding vegetation to grow and mowing (2.5% a.i. *Rodeo* used in dunes at Whitefish Point Unit where this species is a priority)
Tartarian honeysuckle	Medium	Sporadic populations in Units 1-3; at the Headquarters, Visitor Center, and along some edges of farm fields; sporadic management in the past with some success using 2.5% a.i. *Rodeo*; plants do not seem to be thriving
Forget-me-not	Medium	Chicago Farm field and Conlon Field roads only?; treatments using 2.5% a.i. *Rodeo* started in 2011
Silvery cinquefoil	Low	Present, unknown distribution and abundance
Timothy	Low	Present, unknown distribution and abundance
Live-forever	Low	Present, unknown distribution and abundance
Japanese barberry	Low	Present, unknown distribution and abundance
St. John's wort	Low	Present, unknown distribution and abundance
Canada thistle	Low	Present, unknown distribution and abundance
Musk mallow	Low	Present, unknown distribution and abundance

Yellow sweet clover	Low	Present, unknown distribution and abundance
Smooth brome	Low	Present, unknown distribution and abundance
Butter-and-eggs	Low	Present, unknown distribution and abundance
Orchard grass	Low	Present, unknown distribution and abundance
Kentucky blue-grass	Low	Present, unknown distribution and abundance
Catnip	Low	Present, unknown distribution and abundance
Shepherd's purse	Low	Present, unknown distribution and abundance
Ryegrass	Low	Present, unknown distribution and abundance
Queen Anne's lace	Low	Present, unknown distribution and abundance
Ox-eye daisy	Low	Present, unknown distribution and abundance
Tall buttercup	Low	Present, unknown distribution and abundance
Bladder campion	Low	Present, unknown distribution and abundance
Bird's foot trefoil	Low	Present, unknown distribution and abundance
Orange hawkweed	Low	Present, unknown distribution and abundance
Heal-all	Low	Present, unknown distribution and abundance
Yellow goat's-beard	Low	Present, unknown distribution and abundance
Field sow-thistle	Low	Present, unknown distribution and abundance
Plantain	Low	Present, unknown distribution and abundance
Animals		
Beech scale	High	Beech scale (a non-native insect) is part of the Beech Bark Disease Complex, with fungi causing mortality; scale and the complex is found in all northern hardwood stands in Units 1-4; no management known to reduce extent of the scale; forest enhancement efforts used to mitigate the effect
European earthworms	Medium	No management actions, but reducing acreage in farm fields may help suppress populations and reducing the movement of soils may slow further spread
Rusty crayfish	Low	Found in the Driggs River and seems well established in Pine Creek; no known effective management strategies exist
Sea lamprey	Priority	Found in most streams, managed by Marquette Office
Emerald ash borer	Low	Unknown, minimal ash found within the Refuge with some found at Chicago Farm area.

Glossy Buckthorn

Glossy buckthorn (*Frangula alnus,* right) is a small tree invading many Midwestern wetlands. It is native to Europe and Asia, and can be identified by its glossy dark green leaves and gray bark (Voss 1985). The U.S. Forest Service considers glossy buckthorn a "Category One" invasive species because it is highly invasive, invades natural habitats, and replaces native species. Where glossy buckthorn becomes established, it out-competes natural vegetation (e.g., *Alnus*, *Betula*, *Prunus*, *Viburnum*, and *Salix* species), can become a monoculture, and can alter ecosystem patterns and processes. When cut it resprouts vigorously from the stump. Previous studies have indicated that invasions of glossy buckthorn along wetland areas have resulted in decreased plant species diversity and altered hydrology (Devine 1999), with negative implications for wildlife habitat. Active management of glossy buckthorn is critical to minimize the spread of this species to other wetland areas, and to rehabilitate those areas presently impacted.

Reed Canary Grass

Reed canary grass (*Phalaris arundinacea,* left) is a perennial, cool-season grass that grows to 3-6 ft. It has single flowers that bloom in dense clusters form May to August, and are initially green and purple, turning tan as they ripen. While native North American genotypes likely exist, the Eurasian genotype has been widely introduced for hay and forage and can become an aggressive invader (HNF 2005e). Due its aggressive nature, hardiness, and rapid growth, reed canary grass can replace native wetland and wet prairie species. It grows best in disturbed areas and on wet soils and spreads by seed or rhizome. Rapid growth occurs in early spring, seeds ripen and shatter in late June, and growth declines by mid-August.

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria,* right) is an herbaceous perennial with showy purple flowers. It was first introduced in the early 1800s. It invades wetland habitats and moist roadsides. Invaded wetlands often lose 50% of native plant biomass, particularly endangered, threatened, or declining plant species, and in extreme cases native plants can be completely outcompeted (Van Driesche 2002). It is associated with disturbance and can be transported by water, wind, animals, and humans.

Leafy Spurge

Leafy spurge (*Euphorbia esula,* right) is a perennial herb with small, greenish-yellow flowers. Native to Europe and Asia, it was brought to the United States in the late 1890s in impure seed. It is most aggressive in dry soils, but can survive in moist soils as well. It invades fields, grasslands, roadsides, and woodlands. It displaces native vegetation and can produce plant toxins that prevent the growth of other plants. The stems and leaves contain a latex that is toxic to most grazing mammals and can irritate the skin of animals and humans if touched.

Garlic Mustard

Garlic mustard (*Alliaria petiolata,* right) is a biennial herb with heart-shaped, coarsely toothed leaves, white flowers, and seeds in slender pods. Native to northern Europe, it was first documented in the United States in 1868. It is now widely distributed across the eastern and central United States, invading woodlands, roadsides, and urban areas. It is promoted by disturbances, and where established, can dominate eliminating native vegetation.

Common Reed

Common reed (*Phragmites australis,* right) is tall wetland grass. Some genotypes are native, but the aggressive invaders are those of non-native origin. It is found in wetlands as well as along the edges of ponds, lakes, and streams, and along roadsides in drainage ditches. It is a strong competitor and often crowds out other plants. The rapid expansion of populations may be associated with disturbance or environmental stress.

Multiflora Rose

Multiflora rose (*Rosa multiflora,* right) is a perennial shrub from the rose family. Native to eastern Asia, it was introduced for use as a living fence and for wildlife food and cover. It is identified by its arching canes and clusters of flowers ranging in color from white to pink. It can invade woodlands, fields, roadsides, and some wetland habitats. As it grows, it crowds out native plants and can create an impenetrable wall. It is commonly associated with disturbed areas, but due to its tolerance for a variety of conditions, as well as its production of up to a million seeds per year, it spreads easily.

Spotted Knapweed

Spotted knapweed (*Centaurea maculosa,* right) is a perennial herb native to Eastern Europe. It invades grasslands, woodlands, roadsides, and open sites. It is most competitive in dry sunny sites. Spotted knapweed blooms in July and August and produces seed shortly after. In addition, it produces an allelopathic compound that reduces the growth of other surrounding plants, facilitating its ability to crowd out native plants and create monotypic stands. Grazing animals will not eat it, but will instead feed on the native plants reducing their presence further. It has also been found to degrade soil over time by removing much of the moisture and nutrients.

Tartarian Honeysuckle

Tartarian honeysuckle (*Lonicera tatarica,* right) is a deciduous shrub identified by its egg-shaped leaves, white to pink flowers, and presence of a hollow stem. Native to Eurasia, it was first collected in the Midwest in the 1890s. It can be found in woodlands, open areas, and roadsides. Some species can also be found in wetland habitats. Honeysuckle competes with native plants by decreasing light, moisture, and nutrient availability. It can release a toxic chemical that prevents other plant growth.

Forget-Me-Not

Forget-me-not (*Myosotis* spp.*,* right) is a perennial herb with small blue flowers with yellow centers. It is a common invader of roadsides and forest openings; however it can also establish within intact forests. It can become dominant and spread rapidly, decreasing native plant abundance and diversity. Seeds are easily carried by vehicles, humans, and animals, expanding its current distribution.

Beech Bark Disease

Beech bark disease (BBD) is a serious threat to the American beech tree and northern hardwood forests. This disease is caused by an interaction of the exotic sap-feeding beech scale insect (*Cryptococcus fagi*) and at least three species of *Nectria* fungi. Beech scale was first introduced to North America from Europe sometime around 1890. By the 1930s, the scale was found in Maine and the Maritime Provinces of eastern Canada. Other areas of New England and New York were found to have the scale in their forests by the 1960s. By 1975, the scale was in northeastern Pennsylvania. Presently, it is also found in West Virginia, Virginia, North Carolina, Tennessee, Ohio, Ontario, and Michigan. Although the disease has likely been in Michigan for quite some time, it was not until 2000-2001 that beech bark disease was reported in nine counties in Michigan's northern Lower Peninsula and the Upper Peninsula counties of Luce, Chippewa, Alger, and Delta. Beech bark disease can cause reduced leaf size, discolored foliage, dieback, reduced tree growth, reduced mast, and tree mortality.

European Earthworms

European earthworms (family Lumbricidae) were likely introduced with the arrival of early European settlers, and have since been spread widely for use in agriculture and composting. They are now invading natural areas in the northern Great Lakes previously devoid of native earthworms (Shartell *et al.* 2012). Their presence in forested landscapes has been linked to detrimental changes in understory plant biodiversity, community composition, forest floors and soils, and ecosystem processes, deterring restoration and preservation efforts. Studies in similar forest ecosystems elsewhere in the Lake States have suggested that exotic earthworms may have numerous deleterious effects on northern hardwood communities, including ground-nesting songbirds (Loss and Blair 2011). No methods for removal of earthworms exist thus far, however prevention of introduction and spread is essential to maintaining earthworm free conditions in forests currently lacking earthworms.

Objective

Seney NWR's Habitat Management Plan presents the following objective for invasive species management:

*"*By 2020, reduce the area infested with target invasive plant species by 50% from the documented 2007 level and eliminate new infestations of these and other highly invasive species as they occur."

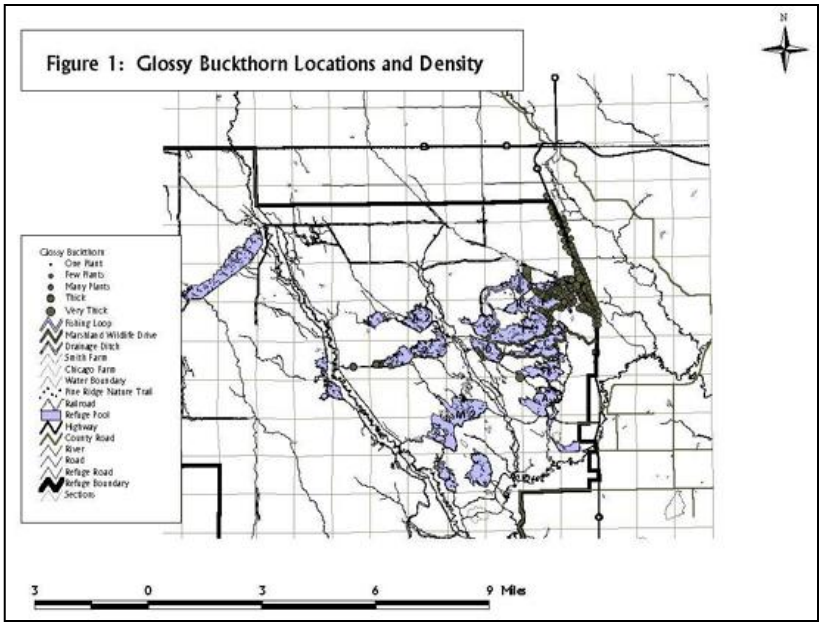


Figure 1. Initial mapping of glossy buckthorn in 1999 indicated that the infestation was densely concentrated around the Headquarters and Visitor Center (Petrella *et al.* 1999).

This objective was set based on what then was known to be the current distribution and abundance of invasive plants (Figure 1). Since then, more surveys (some systematic, see Figure 2, and some not systemic) have been conducted to document the current range and distribution of species. And other studies and surveys too have been used to find where invasive plants (or non-native species, Shartell *et al.* 2012) may be found. For instance, in the forest rapid ecological assessment of Corace *et al.* (2011) virtually no invasive plants were recorded in any forest plots (112 plots), nor were any recorded in the work of Bork *et al.* (2013) or Cohen and Slaughter (2007). All told, the combination of evidence suggest that our current knowledge of the invasive plant community at Seney NWR should be considered fair to good (see Figure 3, below).

Consequently, we suggest that the *measure* of success for management could be found in the efficacy of treatments (e.g., Nagel *et al.* 2008; Corace *et al.* 2008; DiAllesandro 2012) and the amount of effort needed to treat sites repeatedly. For instance, since 2002 the effort to treat dikes of Unit 1 pools (including the Wildlife Drive and the Fishing Loop) has been reduced substantially as a result of the efficacy of treatments.

History of Management

Glossy Buckthorn

At Seney NWR, glossy buckthorn is the main invasive plant species managed. Glossy buckthorn has invaded both anthropogenic and native wetland habitats, and is assumed to have similar negative effects as shown in similar wetlands in Michigan including lower soil pH, fewer vegetative hummocks, less light availability, lower plant coefficient of conservation, less total plant cover, and lower graminoid dominance (Fiedler and Landis 2012).

Glossy buckthorn was first mapped at the refuge in 1999, at which time it was noted that the infestation was densely concentrated around the refuge Headquarters and Visitor Center (Petrella *et al.* 1999; Figure 1, above). Treatment of glossy buckthorn began in 2001 and has occurred regularly since that time, focusing on Unit 1 where most infestations still occur. Highest densities of glossy buckthorn exist in the northeast portion of Unit 1 and decrease moving south and west into the refuge. Mapping of glossy buckthorn in 2007 within pools of Unit 1 shows this pattern of occurrence density (Figure 2).

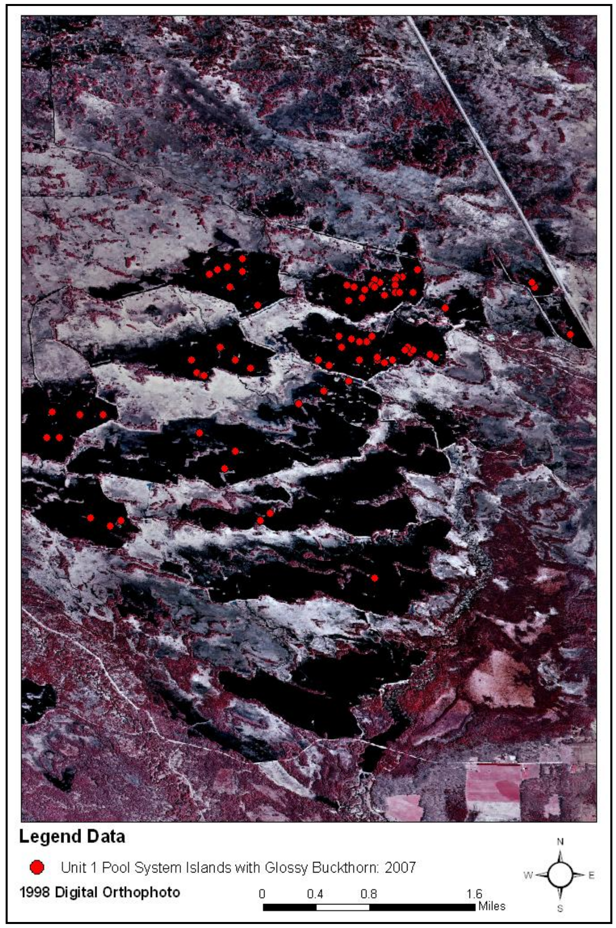


Figure 2. The 2007 distribution of glossy buckthorn on islands within Unit 1. The pattern of density follows that within Unit 1 overall, namely that higher densities are found to the north and lower densities to the south.

Initial treatment of glossy buckthorn consisted of cutting and stump application of 20% a.i. glyphosate, as well as spraying 5% a.i. glyphosate on seedlings and smaller stems. Nagel *et al.* (2008) studied the efficacy of different management methods on reducing the amount and distribution of glossy buckthorn at the Refuge. Stump application of 20% a.i. glyphosate alone proved ineffective one year after treatment, with no difference in sprout density between this concentration of herbicide applied by sponge application, scorching with the flame of a propane torch, or untreated controls. Additional low-volume broadcast application of 5% a.i. glyphosate to resprouts the following year significantly reduced sprout density as compared to scorching and controls, with no difference between scorch treatments and the controls.

Low-volume spraying of the herbicide to extirpate seedlings reduced the number of stems by 96% and 91% one and two years following treatment. There was no difference in seedling density between scorching treatments and the controls. Follow-up work by Corace *et al.* (2008) and DiAllesandro (2012) showed that 2.5%

a.i. *Rodeo* or *Garlon* were also effective and suggested that using both herbicides may reduce the potential of herbicide tolerance while still dealing with problems of efficacy noted by others (e.g., Dornbos and Pruim 2012)

Other Species of Concern

Included in the 1999 assessment of invasive plants at Seney NWR was spotted knapweed, multiflora rose, tartarian honeysuckle, leafy spurge, purple loosestrife, and reed canary grass (Petrella *et al.* 1999). Spotted knapweed was found to exist along most roads within the Refuge and within Walsh and Diversion Farms (Petrella *et al.* 1999). Management for this species has been to allow surrounding vegetation to grow, thereby shading out current populations or treatment by mowing along roadsides. Refuge annual narratives indicate that both multiflora rose and tartarian honeysuckle were planted in Unit 1 between 1937-1943 along ditches, roadsides, and dikes and as habitat and food for wildlife. Scattered plants can be found at locations in Units 1-3, and since 2004 have been treated with use of herbicide application (2.5-5.0% a.i. *Rodeo*). Multiple year treatments have been necessary in some cases, however herbicide application has been successful. Leafy spurge was found to occur at two isolated locations on the refuge in 1999, the J-I Spillway and on Marsh Creek Road south of T-2 West pool (Petrella *et al.* 1999). Other infestations have since been identified, typically associated with bridges or other structures where introduction may have occurred through contaminated fill. Known populations have been treated with herbicide (2.5-5.0% a.i. *Rodeo*) with unknown success. Small populations of purple loosestrife on lands adjacent to Seney NWR have been identified and a few plants have shown up on the Refuge in the past. These have been treated successfully with herbicide application (2.5-5.0% a.i. *Rodeo*) to prevent further spread. Reed canary grass was identified at the refuge in one location between J-1 and G-1 pools (Petrella *et al.* 1999). No treatment has been applied. In the past, non-native phragmites has been identified in Unit 1 and treated successfully using herbicide application (2.5-5.0% a.i. *Rodeo*). Recently it was determined that most phragmites present at the refuge are native genotypes (Corace and DiAllesandro 2011), however a non-native population was identified at C-1 Pool and treated with 2.5% a.i. *Rodeo*. Other non-native populations have been identified at Harbor Island NWR and (likely) Michigan Islands NWR. Forget-me-not was identified at Chicago Farm and Conlon Farm and treated beginning in 2011 using herbicide (2.5% a.i. *Rodeo*), with some success.

Current Conditions

Current known extent of invasion across the Refuge is mapped for forget-me-not, glossy buckthorn, leafy spurge, multiflora rose, and reed canary grass, as well as for purple loosestrife occurring outside of the refuge boundary (Figure 3, below). Most of the invasive species of priority are found in Unit 1 where the hydrology is most altered and the most developed land (pools, roads, buildings) and vehicle traffic exist. Refuge forests, however, are almost completely devoid of invasive plants (Corace *et al.* 2011), but hardwood forests do have issues with non-native pathogens and animals (Shartell *et al.* 2012). In Units 2-4, invasive species are relatively uncommon (Cohen and Slaughter 2007; Bork *et al.* 2013). Nonetheless, more invasive species are expected to arrive in the future. For example, garlic mustard has not been identified at Seney NWR, but known populations exist in the surrounding area such as at Pictured Rocks National Lakeshore located north of Seney NWR. Although invasive animals are less of a problem at Seney NWR, recent studies have documented the distribution, abundance, and potential effects of non-native earthworms within forests at the refuge (Shartell 2012; Shartell *et al.* 2012). Population sizes are relatively small, although some severely impacted stands exist, particularly where agriculture is adjacent such as at Conlon Farm. In addition, beech scale is found in all northern hardwood stands in Units 1-4.

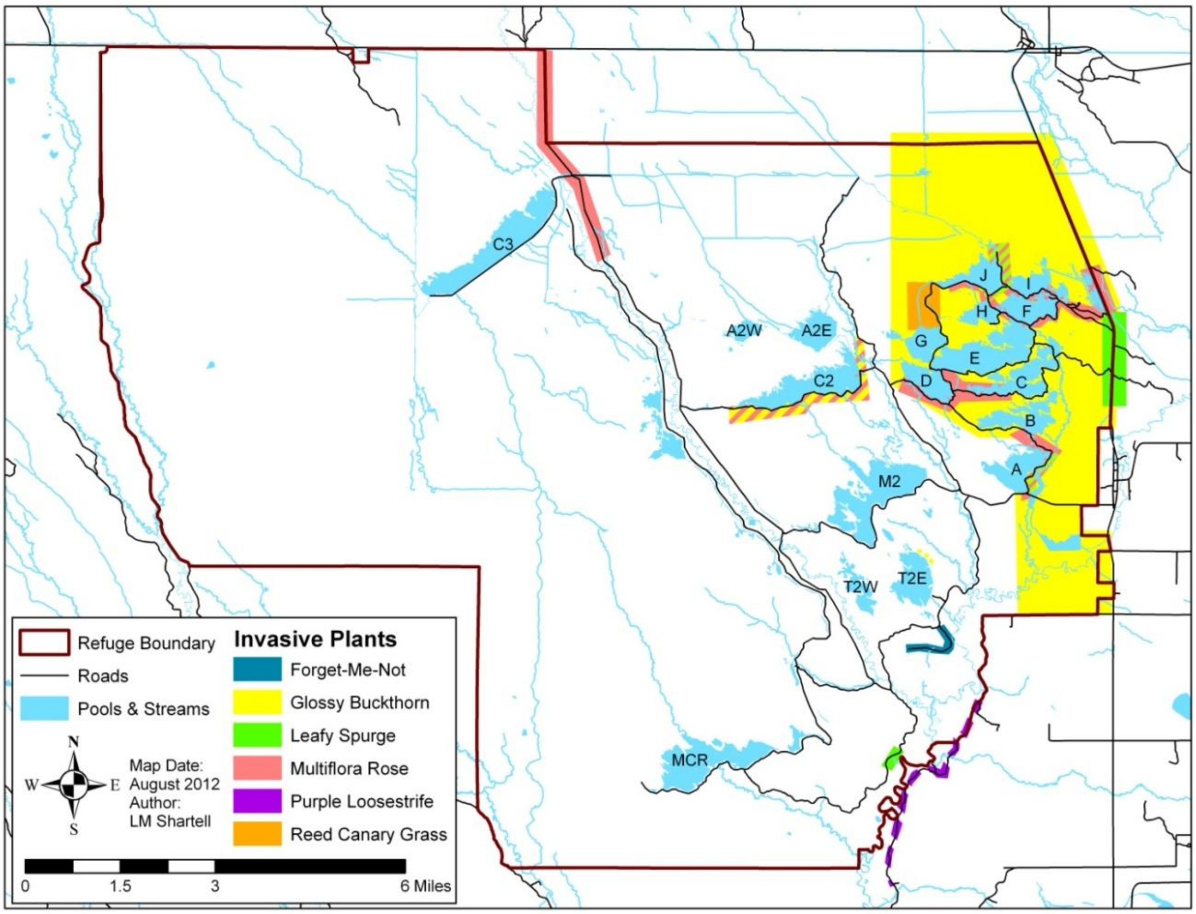


Figure 3. Known occurrences of managed invasive plant species at Seney NWR as of 2012 (see text for more detail). Locations are based on surveys, treatment data, and miscellaneous observations and other published and unpublished documents. Some species (e.g. leafy spurge, multiflora rose, purple loosestrife) are scattered within indicated areas, rather than covering the full area. Tartarian honeysuckle, not shown, occurs in isolated small patches at the Headquarters, Visitor Center, and along some edges of farm fields (i.e., Conlon, Smith, Sub-Headquarters). Also not shown is a patch of leafy spurge near the C-3 Pool gate, I-J Spillway, and along Robinson Rd. near the gravel piles at Sub-Headquarters. Finally, recent evidence suggests that glossy buckthorn can be more accurately thought to be ~1/4 mi further west and is found from Pine Creek Rd., then east. Shapefiles of these data were given to the Midwest Invasive Species Network (MISN). Mixed colors mean that more than one invasive plant is found in that location.

Prevention

To prevent the introduction and further spread of invasive species, vehicle and equipment cleaning will be a priority. All vehicles entering the refuge (non-public access) during the growing season will be required to be cleaned both outside and inside. Vehicle and other equipment cleaning will be required for all Special Use Permits. Current washdown procedures are as follows:

VEHICLE WASHDOWN GUIDELINES (JULY 2012)

Limiting the establishment of invasive plants is a priority for refuge management per the 2009 *Comprehensive Conservation Plan*. Roads and vehicles are major factors in the spread of invasive plants. Access behind locked gates is deemed a privilege and usually requires a *Special Use Permit*. Through inventory data and exchanges with other colleagues, the refuge is generally aware of those invasive plants found at the refuge and on nearby lands.

The following are guidelines for the washdown of all vehicles using refuge roads other than the Wildlife Drive and the Fishing Loop (Unit 1). The goal of these guidelines is to reduce the likelihood of invasive plants becoming established at the refuge; our objectives include removing seeds and soils from vehicles before they enter the refuge. In most instances, these guidelines will be a part of a *Special Use Permit* or an addendum to the same. Oversight for making sure all heavy equipment coming to the refuge is clean is the responsibility of the program associated with that heavy equipment.

1. **Any** vehicle that has been off of paved roads in the eastern U.P. counties of Alger, Delta, Schoolcraft, Luce, Mackinac, and Chippewa or any vehicle coming from **anywhere** else is expected to be thoroughtly washed (inside and out) prior to arrival at Seney.

2. If the above is not practical, a washdown facility has been established directly adjacent to fuel tanks at the shop area. A small shed attached to the backside of the fuel house contains a vacuum, and a water hose is located nearby. This facility is available at any time, day or night.

3. Vehicles must be sprayed (only) with water on the exterior and have their interior vacuumed before going behind locked gates.

4. Consideration should be given to thoroughly washing around the vehicle wheel wells and vacuuming the inside floor mats, etc. The engine compartment is **NOT** to be washed due to oils and other materials that could be freed; the use of any soap is likewise not allowed. The washdown is meant to function as a physical treatment for seed removal.

5. The entire exterior washdown should take between 15 and 30 minutes and should remove the vast majority of visible soil, etc. The vacuuming should take another 15 minutes or so.

6. This procedure need not be done daily, but should be done to meet the requirements of #1, above.

Large refuge equipment (mowers, etc.) should be washed off when moved from Unit 1 (where most infestations exist) to other units.

Treatment

Most active management of invasive species should occur in Units 1-3, with increasing emphasis on reducing the extent of invasive species in Unit 1 and preventing establishment in Units 2-4. Consideration should be made for potential management options in Unit 4 (Wilderness Area) if necessary (see Cohen and Slaughter 2007).

Management methods include biological (natural enemies, shading), mechanical (pulling, cutting, mowing), chemical (herbicide), and fire (natural or prescribed burning, scorching). When possible, biological or passive management are preferred. For instance, many roadside invasive plants are shade intolerant; allowing neighboring vegetation to grow taller and provide shade can be an effective (and cheap) management strategy. In cases where biological management techniques are not available, chemical, mechanical, and prescribed fire strategies should be used to manage infestations. Proper timing of treatment application is also critical to the success of or management and the protection of non-target species.

At Seney NWR, herbicide application is a common treatment method, and the herbicide regularly used (with some efficacy quantified) is *Rodeo* (chemical name glyphosate). *Rodeo* is a water soluble, non-selective herbicide that is approved for aquatic environments. Application can be foliar spray, cut stump, or basal bark. In all herbicide applications care should be taken to limit application on non-target vegetation, as well as overspray into water bodies. To limit negative impacts, the lowest effective concentration of herbicide should be used. For example, a test of differing concentrations of glyphosate (*Rodeo*) in managing glossy buckthorn found that a 1.25% concentration was effective at killing re-sprouts, when commonly concentrations of 5% have been used (Corace *et al.* 2008). Presently, Seney NWR staff use a ~2.5% solution of *Rodeo* (and some 2.5% or

Garlon). In addition, herbicide application should not take place in windy or rainy conditions. The following are recommendations for management and appropriate timing for those species of concern at Seney NWR.

Glossy Buckthorn

Current management methods (mainly application of 2.5% a.i. *Rodeo* or *Garlon* to foliage) have showed success and should be continued, with most work occurring in the late summer and early fall (late July through September) when the plant is most easily identifiable and treatments are the most successful. In sensitive areas, herbicide application should be done in fall or winter rather, as this further limits non-target injury to surrounding vegetation (HNF 2005a). In addition to the use of *Rodeo*, recent studies have shown that low concentration *Garlon* (chemical name triclopyr) can be effective for managing glossy buckthorn seedlings and re-sprouts (DiAllesandro 2012). The use of multiple herbicides may provide benefit if herbicide resistance were to develop in glossy buckthorn (DiAllesandro 2012).

Reed Canary Grass

Recommended methods of management for reed canary grass include application of herbicide, mechanical removal by repeated mowing, or burning (HNF 2005e). Use of herbicide should take place in late summer or early fall as this is when the plant is actively transporting nutrients to the roots (HNF 2005e). This timing or an early spring application can also help to limit non-target injury (HNF 2005e). Combining herbicide with mowing or burning treatments may increase success (HNF 2005e).

Purple Loosestrife

Because purple loosestrife is rare within and surrounding the Refuge effort should be taken to identify new invasions early. Small populations, when identified, should be spot treated with application of herbicide (2.5% a.i. *Rodeo*) to prevent further spread (such as the tract in nw Clare Co., Kirtland's Warbler WMA). Herbicide application is most effective after peak bloom (typically late August, HNF 2005d). Large populations of purple loosestrife are often managed with success using biological control (HNF 2005d), and this method should be considered if purple loosestrife becomes well established at the Refuge.

Leafy Spurge

Known populations should be treated with herbicide (2.5% a.i. *Rodeo* or *Garlon*) every year and monitored until eradicated. Glyphosate application is most effective during mid-summer (June-July), however the risk for undesired effects on non-target plants is greatest during this time (HNF 2005c). A second application of herbicide is recommended in fall before frost (HNF 2005c).

Garlic Mustard

Garlic mustard can be an aggressive invader once established; therefore efforts should be taken to identify populations early. Common habitats that should be monitored include roadsides, disturbed sites, and hardwood forests . Shartell *et al.* (2011) predicted that the highest risk areas for establishment of garlic mustard were located in the southeast portion of the refuge, particularly in hardwood forests in this area and along Manistique River Road (Figure 4). Early detection efforts for garlic mustard should focus on these areas of high risk. Where found, garlic mustard adults should be pulled by hand, preferably before seed set (typically July) and removed from the site in garbage bags (HNF 2005b). First year rosettes and large dense populations should be treated with herbicide (2.5% a.i. *Rodeo* or *Garlon*). Herbicide application should be applied in fall to avoid injury to non-target vegetation (HNF 2005b). Follow-up treatments are necessary each year to ensure exhaustion of the seed bank (HNF 2005b).

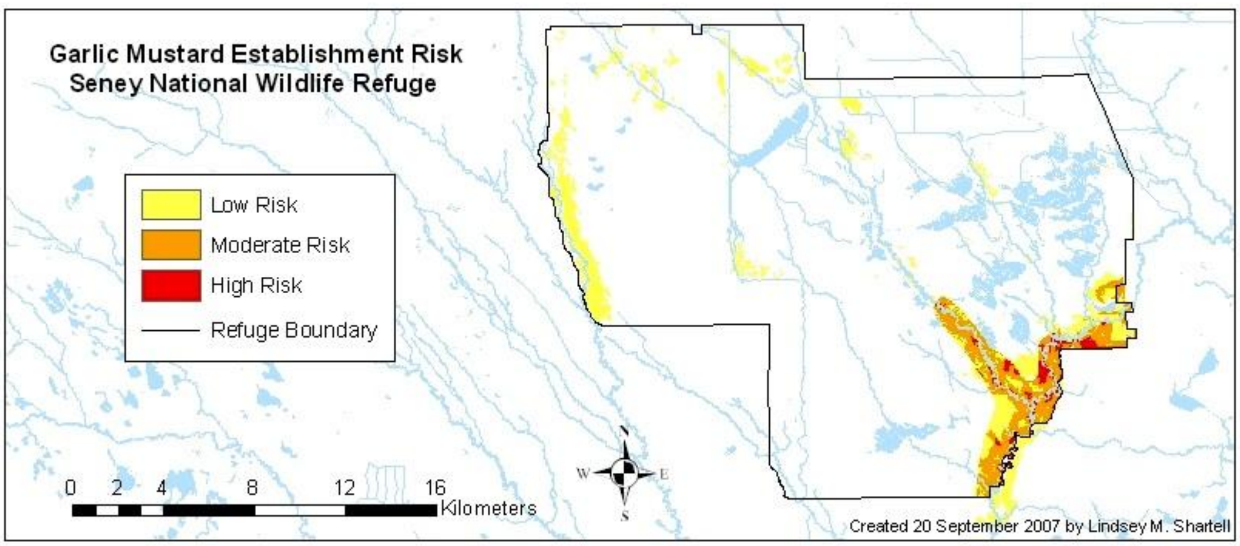


Figure 4. Predicted risk of garlic mustard establishment at Seney NWR (Shartell *et al.* 2011). Detection efforts for new invasions should focus on areas at risk for garlic mustard.

Common Reed

When identified, non-native phragmites should be treated using herbicide (2.5% a.i. *Rodeo* or *Garlon*) and treated areas should be monitored to ensure eradication. The recently identified non-native population at C Pool should be revisited yearly and retreated when necessary. Herbicide application should take place after plants have formed tassels (typically August to September), as this is when translocation into roots is most active (Marks 1986).

Multiflora Rose

Where large individual plants exist surrounding the Headquarters and Visitor Center and elsewhere in Unit 1, cutting and removal is recommended. Smaller roadside infestations (along north end of Driggs River Rd.) can be treated using mowing and herbicide. In other areas, treat with use of herbicide application (2.5% a.i. *Rodeo* or *Garlon*) applied when foliage is present (i.e. at A-1 Pool, along Driggs River Road near Diversion Farm, at G-D spillway, and at I-G spillway). Follow-up at past treatment is necessary sites to ensure success.

Spotted Knapweed

Where possible, passive management should be used at Seney NWR. This will allow surrounding vegetation to grow, thus shading out spotted knapweed. At the Whitefish Point Unit, treat with herbicide (2.5% a.i. *Rodeo* or *Garlon*) during early August. When present along roadsides, mowing before plants seed (typically in late July and August) is recommended to prevent further spread.

Tartarian Honeysuckle

Where large individual plants exist surrounding the Headquarters and Visitor Center and in Unit 1 treat by cutting and revisit with herbicide application if necessary. In other cases herbicide application (2.5% a.i. *Rodeo* or *Garlon*) can be used when foliage is present.

Forget-Me-Not

Little research has been done to assess management methods for forget-me-not. Identification and treatment is easiest in early summer (May-June). Small populations can be pulled by hand. Where present along roadsides or within fields mowing can be used for management. Other populations (Chicago Farm Rd.) can be treated with use of herbicide application (2.5% a.i. *Rodeo* or *Garlon*).

Beech Bark Disease

There is no management known to reduce or remove beech scale, however forest management efforts should be focused to mitigate impacts, such as promoting other species in areas where beech is expected to be lost. It is suggested that beech may show some resistance to beech bark disease (Koch *et al.* 2011), so unaffected trees should be retained as potential sources of seed.

European Earthworms

No known management exists for removing earthworms; however prevention of further spread should be implemented by reducing vehicle and soil movement between sites and restricting the dumping of earthworms when used as fishing bait. Reducing the extent of remnant and existing agricultural fields may help suppress earthworm populations.

Table 2. Invasive plant management actions by month. A schedule for early detection should also be devised based on plant phenology, but is not done here due to limited staff time and lack of available resources.

Management Action and Plant Species	Month						
	April	**May**	**June**	**July**	**August**	**September**	**October**
Planning	X						X
Forget-Me-Not (spraying)		X	X				
Leafy Spurge (spraying)		X	X	X			
Glossy Buckthorn (spraying)				X	X	X	
Multiflora Rose (spraying)				X	X	X	
Tartarian Honesuckle (spraying)				X	X	X	
Purple Loosestrife (spraying)				X	X		
Spotted Knapweed (herbicide at Whitefish Point)					X	X	
General Roadside Species (mowing)			X	X			
Reporting							X

Evaluation and Monitoring

Currently, the Refuge maintains an Excel dbase that describe the general location of treatments and the amount of herbicide used each day. In 2012 the refuge worked with colleagues in the Midwest to evaluate a related database and changes to what treatment data are recorded occurred (see data form in Appendix). This information is used to create maps of species on the refuge and for the Pesticide Use Proposal (PUP) dbase.

With current funding levels, we suggest that the *measure* of success could be found in the efficacy of treatments (e.g., Nagel *et al.* 2008; Corace *et al.* 2008; DiAllesandro 2012) and the amount of effort needed to treat the same site over multiple years. For instance, since 2002 the effort to treat dikes of Unit 1 pools has been reduced substantially as a result of the efficacy of treatments.

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Hiawatha National Forest. 2005b. Non-Native Invasive Plants Species Invasiveness Rank Form: Garlic Mustard (*Alliaria petiolata)*. U.S. Forest Service, Marquette, MI.

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Hiawatha National Forest. 2005d. Non-Native Invasive Plants Species Invasiveness Rank Form: Purple Loosestrife (*Lythrum salicaria)*. U.S. Forest Service, Marquette, MI.

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Appendix: Data Form

DAILY HERBICIDE APPLICATION RECORD
SENEY NATINONAL WILDLIFE REFUGE
1674 Refuge Entrance Rd.
Seney, MI 49883
(906) 586.9851

Applicator's Initials: ____________________________________ **Date:** ________________

Total Treatment Time (hours): _________________________

Herbicide and Percent Active Ingredient: ____

Target Plant Species(s): ____

Temperature (degrees F, circle):	50-60	60-70	70-80	80-90	>90
Wind Speed (mph, circle):	Calm	1-5	5-10	10-15	>15
Precipitation (circle) :	None	Mist			

Total Amount Herbicide Used (oz.): ________________________________

Application Method (circle): Hand Pump/Backpack ATV/Pickup MarshMaster

General Location (unit, road/dike, etc.):____

GPS (DD, NAD83):____

Size of Treated Patch (circle): Isolated Individuals <1 ac. 1-5 ac. >5 ac

Characteristic of Treated Patch (circle): Individuals Discontinuous Patch Monoculture

Characteristic of Treated Patch (circle): Road or Dike Wetland-Riparian Upland

Useful Numbers/Dilution Rates:

128 liquid ounces per gallon

19 part water : 1 part 53.8% a.i. *Rodeo* = ~2.5% a.i. *Rodeo* (no surfactant)

24 part water : 1 part 61.6% a.i. *Garlon 4* = ~2.5% a.i. *Garlon 4* (no surfactant)

Marsh Master Herbicide Work Protocol for Invasive Plant Management at Seney NWR

1. Setup & Cleanup:

Setup of the sprayer unit will be done by the Marsh Master operator with assistance from the sprayer/crewmember (staff of the Applied Sciences Program). The machine will be cleaned by the operator and crewmember/sprayer working together. It will be assumed that the machine will be cleaned and returned to a “fire-ready” state after each use on the day it is used. Cleaning will require a minimum of 1-1/2 hours and may require additional time. Time required to clean the machine is driven by the amount of mud and vegetation on the machine after spraying. Additionally, the invasive plants the machine is exposed to influence the amount of clean up time. On those occasions where the machine will be used to spray for several days in a row limited cleaning may be approved by the Fire Management Officer (FMO).

2. Work Duration:

There should be no less than 4 hours of work planned for any given day. This does not include setup, transport, or cleaning time. All work (setup and cleanup) should be planned for completion in a normal 9 or 8 hour work day.

3. Target Area Maps:

Maps will be provided to Marsh Master operator by Applied Sciences Lead as requested by operator if treatment areas change significantly. They will be full page (8-1/2”by 11”) in digital JPEG format with treatment areas clearly identified. Resolution should be sufficient to identify access points and potential hazards in treatment areas.

4. Machine Oversight:

Marsh Master operator is in charge until the work is complete. This is to include from setup to cleanup of the machine. Overall oversight of operations is by the Fire Management Officer and oversight of spraying locations, etc. by the Refuge Biologist.

5. Herbicide Clean Up:

Herbicide mixing, spraying, and cleanup is the responsibility of spray operator under the direction of Applied Science Program and shall include removal of unused herbicide from the slip-on sprayer unit used on the Marsh Master.