Conservation Planning for the Grayling Subdistrict of Michigan

by

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Abstract

The Nature Conservancy of Michigan has identified the Grayling Subdistrict of northern Lower Michigan as an important conservation priority. Due to the unique physiography, surficial geology, and climate, the Grayling Subdistrict contains rare ecosystems that support many endemic and endangered natural communities and species. Utilizing the landscape ecosystem approach and The Nature Conservancy's Five-S Framework and Conservation Action Planning workbook, we drafted a conservation plan to guide the Conservancy's future actions in the subdistrict. Through extensive literature reviews, GIS analysis, meetings with public agency staff, and a series of phone interviews with land managers and scientists, we completed The Nature Conservancy's Conservation Action Planning workbook. First, we identified the terrestrial conservation targets—jack pine barrens, dry sand prairies, nonforested wetlands, rare turtles of concern *(Emys blandingii, Glyptemys insculpta)*, the eastern massasauga *(Sistrurus catenatus catenatus),* and the secretive locust *(Appalachia arcana)*—the most threatened natural communities and species of the subdistrict. Next, we determined the stresses and sources of stress, or threats. Key threats include altered fire regimes, habitat fragmentation, timber plantations, single-species management of the endangered Kirtland's warbler, invasive species, poaching, and inappropriate land management. Lastly, we drafted potential strategies and actions for conservation of the targets. We recommended that the Conservancy initiate a conservation program in the subdistrict and establish a multi-stakeholder Grayling working group that could work to increase the amount of prescribed fire, pursue regional restoration goals for jack pine barren and dry sand prairie restoration, jointly apply for funding, conduct research, and share resources. Other recommendations include setting up an ecosystem-based Kirtland's warbler demonstration area, partnering with environmental education organizations, and pursuing protection of high-quality wetlands at Camp Grayling.

Acknowledgments

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Finally, we thank our family and friends for their support and encouragement throughout this process.

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Part I: Introduction and Overview

Chapter 1: Introduction

Introduction

There is a general consensus in the scientific community that the current global extinction rate is catastrophically high, between 1,000 and 10,000 times the presumed extinction rate prior to human expansion and dominance of Earth (Wilson 2001). In the United States alone, nearly one-third of all native species are currently at risk of extinction, and more than 500 species are already extinct or missing (NatureServe 2005). The leading threats to native species are habitat destruction, habitat degradation, and invasive species. Other threats include poaching and pollution. All threats stem from unprecedented human population growth, resource extraction, and expansion into previously undeveloped lands. These threats may impact entire ecosystems, as well as the individual species that are parts of them. Because ecosystems provide invaluable resources such as clean air and water, energy, and raw materials, decreased ecosystem and biotic diversity degrades and threatens the quality of life on earth. Additionally, the intrinsic value of intact, functioning, diverse ecosystems will be compromised if human population and consumption continues to increase.

In response to the rising numbers of species extinctions, the field of conservation biology has emerged. Conservation biology, while a relatively new term, has existed in the minds of foresters and other scientists in the United States since the 1800s. As a discipline that combines academic science and human ethics, it has changed over time from the preservationist views of Henry David Thoreau and John Muir to the anthropocentric views of Gifford Pinchot and Theodore Roosevelt to the aesthetic and ethical values of Aldo Leopold (Leopold 2004; Rowe 2002; Smith 1998). Conservation biologists today act in response to the "biodiversity crisis," a term used to describe the current extinction events attributed to exponential human population growth and its subsequent overexploitation of natural resources (Meffe 1997). The goal of conservation biology is to preserve global biodiversity while allowing for sustainable development of human interests (Primack 2004).

Governments around the world have attempted to implement the principles of conservation biology through international conventions, public land protection, and legislation. In the United States federal laws such as the Endangered Species Act have been enacted to safeguard species at risk of extinction. Additionally many states have adopted legislation to protect locally threatened species. Federal and state agencies, such as the United States Fish and Wildlife Service (USFWS), the United States Department of Agriculture (USDA) Forest Service and state Departments of Natural Resources (DNR) work to combat the loss of native species through appropriate public land management. Unfortunately, many government efforts represent a piecemeal approach because each agency is limited in scope and has its own strategy for management depending on leadership, statutory guidance, and funding. In landscapes where there is a patchwork of public and private land ownership, communication and collaboration are necessary for effective ecosystem management and species recovery.

In an effort to protect global biodiversity many private not-for-profit conservation organizations have formed such as the World Wildlife Fund (WWF), Conservation International (CI), and The Nature Conservancy (TNC). These major conservation organizations employ various conservation strategies on multiple spatial and geographic scales. Conservation International, for example, focuses on protecting global hotspots of biodiversity—areas with high concentrations of threatened or endemic species, a majority of which fall outside of the United States (Conservation International 2005). Meanwhile, The Nature Conservancy has recently begun

working at an international scale, but has mainly focused on biodiversity conservation in the United States over the last 50 years.

Ecosystem and Biotic Diversity (Biodiversity)

In its most direct form, biodiversity is the presence of the plants and animals found in a specific area. There are numerous definitions of biodiversity that attempt to capture the same basic idea—the variety and variability among living organisms at all levels of biological organization (Boyle 1991). The Nature Conservancy defines biodiversity as "the full range of natural variety and variability within and among living organisms, and the ecological and environmental complexes in which they occur. It encompasses multiple levels of organization, including genes, species, communities and ecosystems" (TNC 2004). However, Barnes et al. (1998) indicate that although many definitions of biodiversity encompass landscapes and ecosystems, biota are not ecosystems. Because biodiversity depends on ecosystem diversity, ecosystem diversity should receive special and separate consideration. Ecosystem diversity is defined as the "kind and number of ecosystems in an area and includes the patterns of associations of ecosystems with one another and the recurrence of these patterns in a given landscape" (Barnes et al. 1998).

Frequently, land managers and conservation groups like The Nature Conservancy focus their conservation efforts on biota, plants and animals, at local and global scales. Our conservation plan will focus on biota and vegetative community types in the context of the landscape ecosystems that support them, specifically the Grayling Subdistrict of the High Plains District of northern Lower Michigan.

The Nature Conservancy (TNC) and the Five-S Process

The mission of TNC is to "preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive." Founded in 1951 by an association of professional ecologists looking to transform their knowledge of the natural world into efforts to protect it, TNC has since grown into a leading conservation organization with programs in all 50 states and 27 countries (TNC 2006c). In 1955, TNC purchased its first property, a 60-acre parcel in upstate New York, beginning a legacy of land protection through private action. To date, the Conservancy has protected more than 117 million acres of land and 5,000 miles of rivers around the world. The Nature Conservancy also operates more than 100 marine conservation projects in 21 countries and 22 states (TNC 2006c). The Conservancy pursues non-confrontational solutions to biodiversity conservation, including working with willing sellers and donors to protect species' habitat through gifts, exchanges, conservation easements, management agreements, purchases, and management partnerships (TNC 2006c). Currently, the organization has approximately 1 million members and supporters and more than 1,500 dedicated volunteers and 3,200 employees, 720 of whom are scientists (TNC 2006b).

In 1997, TNC adopted a conservation approach called *Conservation by Design: A Framework for Mission Success* (see figure 1). Designed by a group of Conservancy scientists, *Conservation by Design* established a framework for strategic, targeted protection of all viable native species and communities (TNC 2003). *Conservation by Design* encapsulated the following ideas (TNC 2004):

1. setting priorities through ecoregional planning and global habitat assessments

2. developing strategies at multiple scales to address ecoregional priorities and global threats
3. taking direct conservation action
4. measuring conservation success

Figure 1. Diagram of The Nature Conservancy's Conservation Approach (TNC 2004).

In order to translate the fundamental concepts of *Conservation by Design* into a workable procedure and planning tool, the Conservancy subsequently developed the *Five-S Framework for Site Conservation*. The *Five-S Framework for Site Conservation* is a step-by-step procedure for conservation planning that includes the following components (TNC 2003):

- Systems: the conservation targets occurring at a site, and the natural processes that maintain them, which will be the focus of site-based planning
- Stresses: the types of degradation and impairment afflicting the system(s) at a site
- Sources: the agents generating the stresses
- Strategies: the types of conservation activities deployed to abate sources of stress (threat abatement) and persistent stresses (restoration)
- Success: measures of biodiversity health and threat abatement at a site

This approach integrates the collective experience and knowledge of the organization into a single, unified framework for the site conservation planning *process*. The Five-S process assesses contextual information about a site (i.e., systems, stresses, and sources) and results in two specific *products*—conservation strategies and measures of conservation success (TNC 2003). More detailed information on the steps associated with each of the Five S's are provided in chapter 6. As a result of this process, the systems-stresses-sources assessment, the conservation strategies, and measures of conservation success are documented in a site conservation plan.

The Nature Conservancy of Michigan

The Michigan Chapter of The Nature Conservancy was founded in 1980. The chapter currently has over 26,000 members and 350 volunteers. In the past 25 years, the chapter has helped protect over 260,422 acres across the state through direct land purchase, partnerships, and conservation easements (TNC 2006a). The chapter currently owns 35 preserves, totaling

45,887 acres. Chapter staff hope to systematically complete the Five-S process for all major ecosystems in the state and have identified the northern Lower Peninsula as a priority area for conservation. To date, the chapter has been involved in larger conservation efforts in this region, but has yet to complete any detailed conservation plans. The conservation plan for the Grayling Subdistrict is also the chapter's first in-depth landscape scale plan. TNC staff aim to build upon this effort in undertaking additional landscape-scale planning efforts.

Part I: Introduction and Overview

Chapter 2: Approach, Goals, and Objectives

Mission, Goals, and Objectives

Mission

We will develop a conservation plan for the rare terrestrial communities and organisms found within the Grayling Subdistrict of the High Plains District of northern Lower Michigan by integrating ecological, sociological, and managerial information to produce a specific set of conservation strategies for the region that will be used in future conservation efforts by The Nature Conservancy (TNC).

Goals and Objectives

Goal 1: Identify targets for conservation and conduct a viability assessment of the selected targets

- **Objective:** To identify conservation targets, both communities and organisms, and their occurrences in the Grayling Subdistrict at appropriate ecosystem scales.
- **Objective:** To prioritize, characterize, and spatially integrate conservation targets (communities and organisms) based on their spatial occurrence, physiography, surficial geology, climate, and soil, and to determine the key attributes and current status of these targets.
- **Objective:** To conduct a viability assessment for each conservation target by determining its key attributes and indicators.
- **Objective:** To determine the current and desired status of each selected target.

Goal 2: Identify the stresses and sources of stress (threats) to the ecosystems of the Grayling Subdistrict

- **Objective:** To identify the threats to the targets and the sources of those threats at regional and local ecosystem scales.
- **Objective:** To determine the social, political, and managerial attributes of communities and organisms and to integrate them with the stresses and sources of stress.

Goal 3: Produce conservation strategies aimed at removing stresses and restoring ecosystems

- **Objective:** To produce conservation strategies that can be disseminated to land managers and that encourage a collaborative process among stakeholders.

Our hope is that we will have a positive impact on conservation within the Grayling Subdistrict through our work for TNC and our continued interaction with other stakeholders. By consolidating the many sources of information into a comprehensive document, we hope to lay the groundwork for the organization's future work in the area. In addition, through the process of developing a conservation plan for TNC, we hope to foster a positive, collaborative relationship between TNC and the many stakeholders in the Grayling Subdistrict.

The Landscape Ecosystem Approach

In creating this conservation plan for the Grayling Subdistrict of northern Lower Michigan, we followed the landscape ecosystem or geoecosystem approach of Rowe (1961, 1992, 1998). According to Rowe, "Organisms do not stand on their own; they evolve and exist in the context of

ecological systems that confer those properties called life" (1989). This approach defines ecosystems as topographic units: volumes of land and air plus organic contents extended aerially over a particular segment of the earth's surface (Rowe 1961). Each ecosystem as a whole has structure, including atmospheric layers, landforms, and soil layers, with organisms sandwiched at their interface (Rowe 1992).

This approach has been used extensively in characterizing regional and local landscape ecosystems and the biota they support (Albert et al. 1986; Albert 1995; Walker et al. 2003; Kashian et al. 2003). It has been applied in Germany and Canada since 1948 and is also the operating land classification principle of the USDA Forest Service (Barnes 1984; Avers 1994).

We considered landscape ecosystems of several scales. Ecological systems are subdivided into nested hierarchical units, the largest being the entire Earth and the smallest being a local site supporting its interacting organisms (figure 2). These units include physiographic systems (outwash plain, ice-contact terrain, moraine), landform-level ecosystems (i.e., landforms), and landscape ecosystem types. In this project, we concentrated on the local ecosystems within District 8 and Subdistrict 8.2 of Albert et al. 1986 (Subsection VII.2 and Sub-subsection VII.2.2 of Albert 1995). The Grayling Subdistrict of the High Plains District is unique due to the landforms, soil, and vegetation that create the site-specific ecosystems or "habitat" where organisms occur.

Principal ecosystem components that determine the physical and biotic components at the regional level include geology, physiography, climate, soil, and vegetation (Albert et al. 1986; Barnes et al. 1998). These factors interact to determine the specific ecosystems that support the rare and endangered species of the Grayling Subdistrict. Because physiography controls regional climate and is the most stable of ecosystem factors it is the single most important ecosystem component to consider for practical conservation and management. Physiography has two major components: the form of the land and the parent material (in this case, glacial deposits primarily of sand and gravel). Physiography exhibits control on the local macroclimate and microclimate and on soil development. For example, the Kirtland's warbler is one of the best-known species to inhabit the High Plains District, especially Subdistrict 8.2. It lives exclusively in outwash plain and ice-contact landforms with sandy, excessively drained soils that support patchy young jack pine stands. Depending on the drainage, elevation, and temperature, the jack pines in different areas grow at different rates—faster growing trees greatly reduce the amount of time that warblers inhabit the landforms (Kashian et al. 2003).

Because of the structure of the TNC's planning process, we needed to identify specific targets for conservation. While other TNC planners have used a species or community-level approach, which focuses on the animals and plants of a particular area, the landscape ecosystem approach enabled us to recognize the geologic and climatic features that make each ecosystem unique and able to sustain the rare species that live there. We feel that by considering all communities-types and organisms in the context of the ecosystems that support them, we were able to take a more holistic approach to protection of ecosystem and biotic diversity. In addition, the landscape ecosystem approach allowed for a study of land ownership and management practices at a large scale, making apparent the gaps in ownership and management that TNC may be able to bridge in the future.

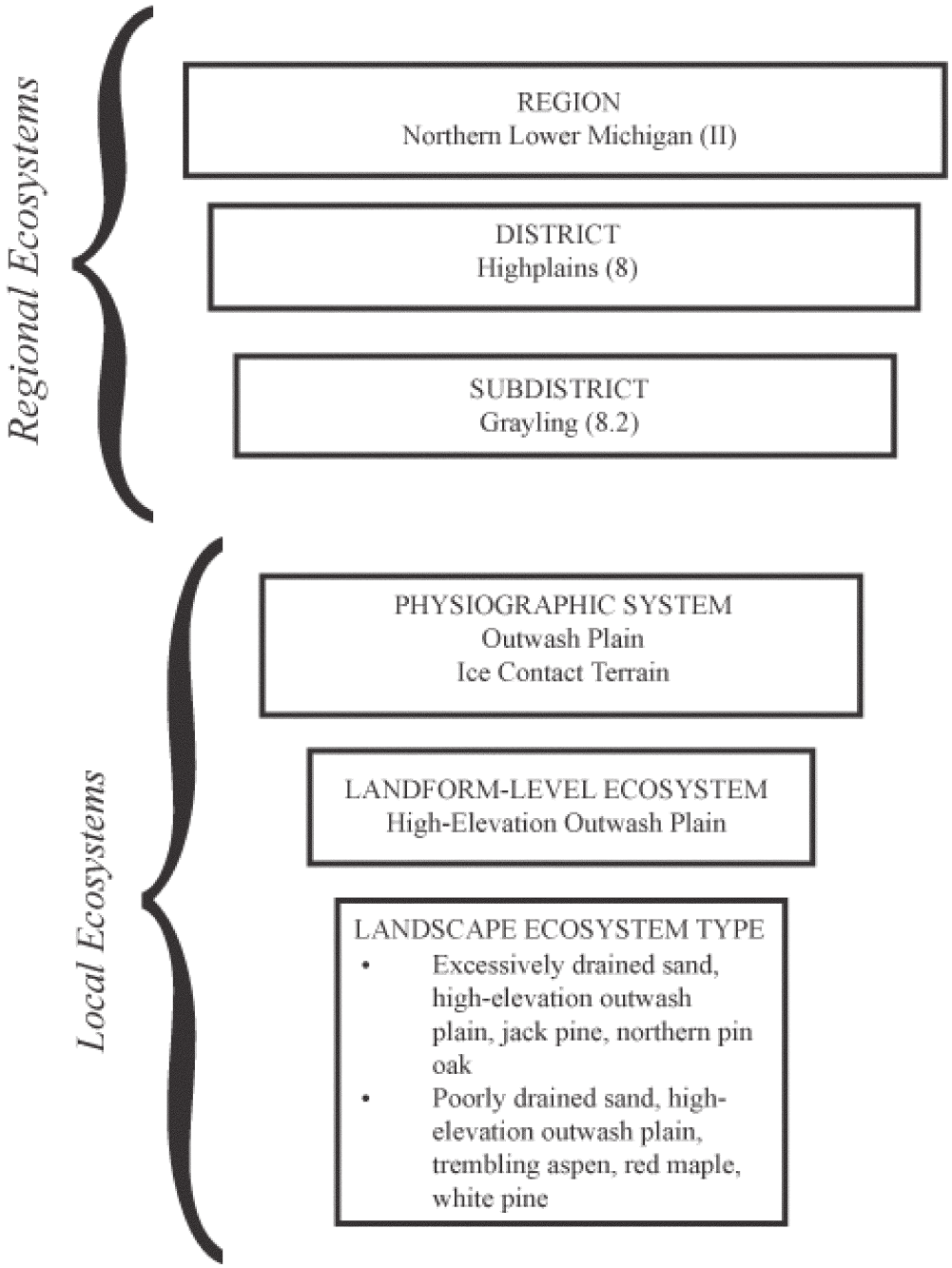

Figure 2. The hierarchical order of landscape ecosystems (modified from Walker et al. 2003).

Part II: The Grayling Subdistrict

Chapter 3: The Study Area

Background

As described in chapter 2, this project is guided by the ecosystem concept. Ecosystems are natural holistic units that can be defined and mapped on a large regional scale or at a small local level (Albert et al. 1986; Bailey 1996). The evolution of the ecosystem concept prompted scientists and researchers to develop systems for classifying and mapping the nested hierarchy of ecological systems that exists on Earth. The goal of landscape ecological classification and mapping is to subdivide large areas of land into distinct landscape ecosystems based on similar ecosystem components such as climate, physiography, soil, and vegetation. Ecological classification systems provide a useful framework for integrated resources management and planning, biological conservation, and comparisons of species composition and productivity among ecosystems (Albert et al. 1986, Corner and Albert 1999).

The ecoregional mapping process across the United States was developed by Bailey in the 1980s (Bailey 1995). Within the state of Michigan, Albert et al. (1986) developed an ecological classification system titled *Regional Landscape Ecosystems of Michigan* that has been widely used by land managers (figure 3). The classification and map system includes ecosystem units (from large to small) termed "region," "district," and "subdistrict."

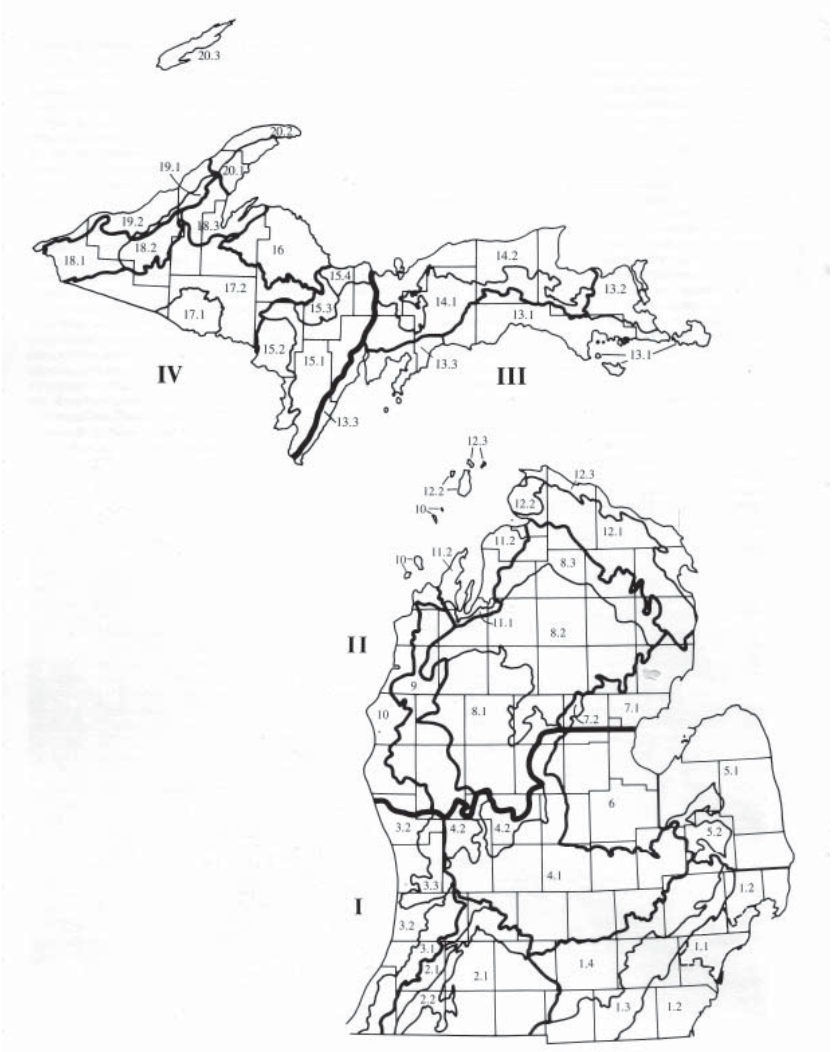

Figure 3. Map of the regional landscape ecosystems of Michigan. Three hierarchical levels are mapped: Regions I–IV, Districts 1–20, and Subdistricts within many districts (Albert et al. 1988).

In 1994, the Forest Service adopted the ecosystem management principle and developed a national classification system based on a hierarchy of landtype ecosystems including (from largest to smallest): domain, division, province, section, subsection, landtype association, ecological land type, and ecological land type phase (Avers et al. 1994) and in 1995, commissioned Albert to expand his 1986 classification to include the states of Wisconsin and Minnesota, which resulted in a change in the ecosystem numbering to match that of the Forest Service. Within Michigan, the ecological boundaries of these two classification systems overlap with the district level corresponding to the section level and the subdistrict level corresponding to the subsection level. Based on the work of these two classification systems, the Michigan Natural Features Inventory (MNFI) has further mapped and described Michigan's ecosystems at the section and subsection level. In addition, the MNFI has detailed sub-subsection and landtype association levels (Corner and Albert 1999).

In delineating the boundaries of our project area we chose to follow the ecological boundaries identified in the ecological classification systems of Albert et al. (1986) and the MNFI (Corner and Albert 1999). Our project boundaries coincide with the Grayling Subdistrict (8.2) of the Highplains District as described by Albert et al. (figure 4). The same regional ecosystems are referred to in Albert 1995 in the landtype associations document as Sub-Subsection VII.2.2: Grayling Outwash Plain. For the purposes of this project we will refer to the project location as the Grayling Subdistrict, the subdistrict, or the region.

Figure 4. Map of the regional landscape ecosystems of Michigan with Subdistrict 8.2 outlined in blue (Albert et al. 1986).

The Grayling Subdistrict of northern Lower Michigan is a diverse, regionally significant ecosystem. Approximately 10,525 square km (4,061 square mi) in size (Corner and Albert 1999), it is the largest subdistrict in northern Lower Michigan. It has one of the most extreme climates in the state due to its interior location, northern latitude, and relatively high elevation (900–1580 ft). Furthermore, the 115-day growing season is the shortest in the state and late spring frosts are fairly common (Albert et al. 1986). Geologically, it is composed of glacial outwash plain (60%), sandy ice-contact terrain (20%), rolling till plain (8%) and steep end moraines (6%) (Corner and Albert 1999).

The subdistrict also supports several large lakes and ridges dissected by many rivers (Albert et al. 1986). Three of the state's major rivers—the Manistee, the AuSable, and the Muskegon—and their tributaries originate in the Grayling Subdistrict. Many of the state's largest inland lakes were formed in this subdistrict by large ice blocks left by retreating glaciers during the last glaciation. These kettle lakes include Houghton and Higgins Lakes, Lakes Margrethe and St. Helen, and numerous smaller lakes (Corner and Albert 1999).

Most of the glacial outwash plain in the subdistrict occurs between 1050 and 1300 ft (Albert et al. 1986). The sandy outwash deposits are variable in depth ranging from hundreds of meters to only one or two feet. Near Higgins and Houghton Lakes the clay subsoil is exposed near the surface causing a perched water table and a large wetland complex called Dead Man Swamp (Albert et al. 1986; Corner and Albert 1999). A majority of the outwash plain in this subdistrict (70%) is well or excessively well drained while a smaller percent is poorly drained (17%) (Corner and Albert 1999). Historically, the predominant vegetation of the well drained outwash plain was mixed xeric conifer forests and jack pine barrens (43%), which occurred on the most fire-prone sites. Mixed forests of white pine, conifers, or oak (22%) occupied the sites that were less fire prone, while deciduous forests (26%) occurred on the least fire-prone sites. Historically, fire was frequent and often widespread in this landtype (Albert et al. 1986).

Today, the well drained outwash plain is still mostly conifer forests (36%), yet decades of fire suppression and human disturbance in the region have altered the forest structure. Mature jack pine forests and pine plantations now dominate the landscape and the extent of open jack pine barrens has been greatly reduced (Corner and Albert 1999). The amount of deciduous forest on the well drained outwash is similar to its extent in presettlement, yet the percent of aspen/white birch forest has increased from 1 to 16%.

Historically, poorly drained glacial outwash plain was largely conifer swamps. Today, aspen/white birch forests now are the most common forest type (30%) and the percentage of conifer swamps has decreased from 53% to 18% (Corner and Albert 1999).

The ice-contact terrain adjacent to outwash plains comprises approximately 18% of the subdistrict and often occur as large, abrupt sandy ridges within the outwash plain. The historic vegetation of these ice contact ridges was primarily American beech-sugar maple forests (39%), dry-mesic forests (33%) and dry conifer forests of jack pine (25%) (Corner and Albert 1999). The excessively well drained sandy ridges are more fire prone and thus historically supported conifer forests. The ridges with mesic soil conditions or those protected from the fires by lakes or wetlands supported deciduous forests. Today the amount of hardwood forests of the ice-contact ridges remains the same but the conifer forests have been reduced from 58% to 12% (Corner and Albert 1999).

The remainder of the subdistrict is composed of till plain and end moraines. In presettlement times approximately 85% of the vegetation of the till plains was American beech/sugar maple forest. Today the till plain is highly fragmented into numerous cover types including forests, cropland, and old fields. End moraines were also predominately composed of American beech/sugar maple forests (55%), although a portion were dry-mesic (20%) and dry conifer forests (19%). Now, approximately one-half of the end moraines are American beech/sugar maple while the remainder is fragmented into cropland, old fields, and other forest types (Corner and Albert 1999).

Due to the unique physiography, climate, and fire disturbance of the Grayling Subdistrict, it is home to several rare and endemic landscape ecosystem types and organisms. These include several dry ecosystems supporting sand prairies and pine barrens. These communities have been designated as imperiled on a global and state scale based on rarity by NatureServe. Numerous rare plants and animals also depend on this area of the state, including nearly all of the breeding pairs of the Kirtland's warbler *(Dendroica kirtlandii),* which are primarily located in Subdistricts 8.2 and 7.1. The federally endangered bird breeds solely in stands of young jack pines or pines associated with northern pin oak *(Quercus ellipsoidalis)* (Walker et al. 2002; Kashian et al. 2003). Several other species of special conservation concern occur in the Grayling Subdistrict and are detailed in chapter 5.

Part II: The Grayling Subdistrict

Chapter 4: Stakeholders and Socioeconomic Factors

Overview

In addition to its unique ecological features, the Grayling Subdistrict of northern Lower Michigan is distinguished by a high proportion of public land, large numbers of seasonal homes, and many opportunities for outdoor recreation. According to the 2000 U.S. Census, the total population of the region is approximately 159,000 and is 97% white. The residents are employed in a variety of occupations. Natural resources, tourism, and recreation are prominent features of the regional economy today. Another prominent feature of the subdistrict is the Camp Grayling National Guard facility, the largest military installation east of the Mississippi River (Michigan Army National Guard 2005). Occupying 147,000 acres, over 20,000 military personnel are trained there each year. It is one of the largest employers in Crawford County.

Once covered by "towering white pine forests," the Grayling Subdistrict was at the heart of the Michigan logging boom in the mid to late 1800s (Grayling Visitors Bureau 2004). The region was suitably located for shipping and trade because the Manistee and Au Sable Rivers originate in the center of the Subdistrict and flow outward to Lakes Michigan and Huron. The fur trade also prospered during this period. After the logging boom ended in the early 1900s, the resource-based economy has shifted towards tourism and more sustainable forest management. In the 1960s, the construction of Interstate 75 greatly increased access to northern Lower Michigan for vacationers, tourists, and industry (Grayling Visitors Bureau 2004). Regional booms in seasonal home construction occurred in the 1970s and late 1980s, and now several counties contain more seasonal homes than permanent residences (Stynes et al. 1997). Popular recreational activities include snowmobiling, skiing, off-road vehicle use (ORVs), fishing, hunting, canoeing, and camping.

Eight counties make up most of the Grayling Subdistrict although parts of seven other counties are also included (figure 5). Many of these contain high proportions of public land, particularly state forests and the Huron-Manistee National Forests. This composition is important because these counties receive annual payments from the state and federal government to compensate them for the lost tax base due to public lands. Average payments to counties in the subdistrict—based on timber receipts on the Huron-Manistee National Forests—range from $1.59 to $123,000 annually (USDA Forest Service 2006). Payments in lieu of taxes from the state of Michigan to counties in the subdistrict range from $100,000 to over $500,000 annually (MI DNR 2004c, 2005g), corresponding with the percentage of state land in a county.

The landscape is a patchwork of public and private ownership, with the largest landowners being the Michigan Department of Natural Resources (MI DNR) and United States Department of Agriculture Forest Service (USDA Forest Service) (figure 6). The area includes parts of the Huron-Manistee National Forests, several state forests, military land (the Michigan National Guard), and state parks. Much of the public lands are managed for timber, game, and wildlife; they are also interspersed with private land holdings—many of which are seasonal vacation homes. Public land agencies across the area have coordinated management activities and intensively managed parts of their lands to create appropriate habitat for the recovery of the Kirtland's warbler. Aside from the Kirtland's Warbler Recovery Initiative, however, few broad conservation efforts exist in the area and cross-agency coordination has been limited. In addition, management efforts in the subdistrict and in general have typically focused on individual species—such as the Kirtland's warbler—rather than the regional and landscape ecosystems in which species reside. Agency staff and others have noted that management practices change across ownership boundaries, so better coordination is needed between agencies to truly man-

age ecosystems rather than administrative units. The characteristics and land management objectives of these public and private landowners have important implications for future conservation and restoration efforts in the Grayling Subdistrict.

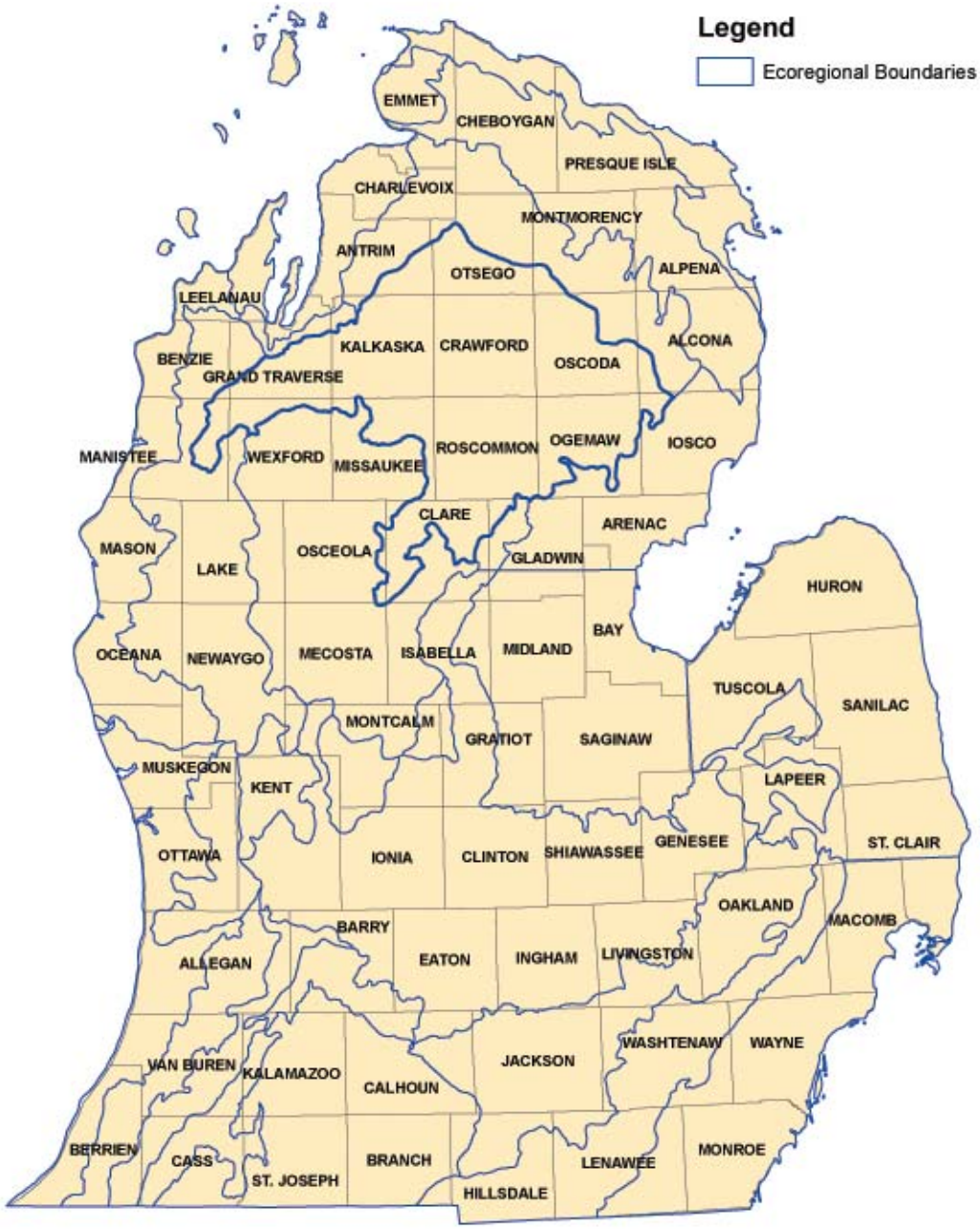

Figure 5. Map of Michigan counties with the Grayling Subdistrict outlined in bold (Michigan Geographic Data Library 2005).

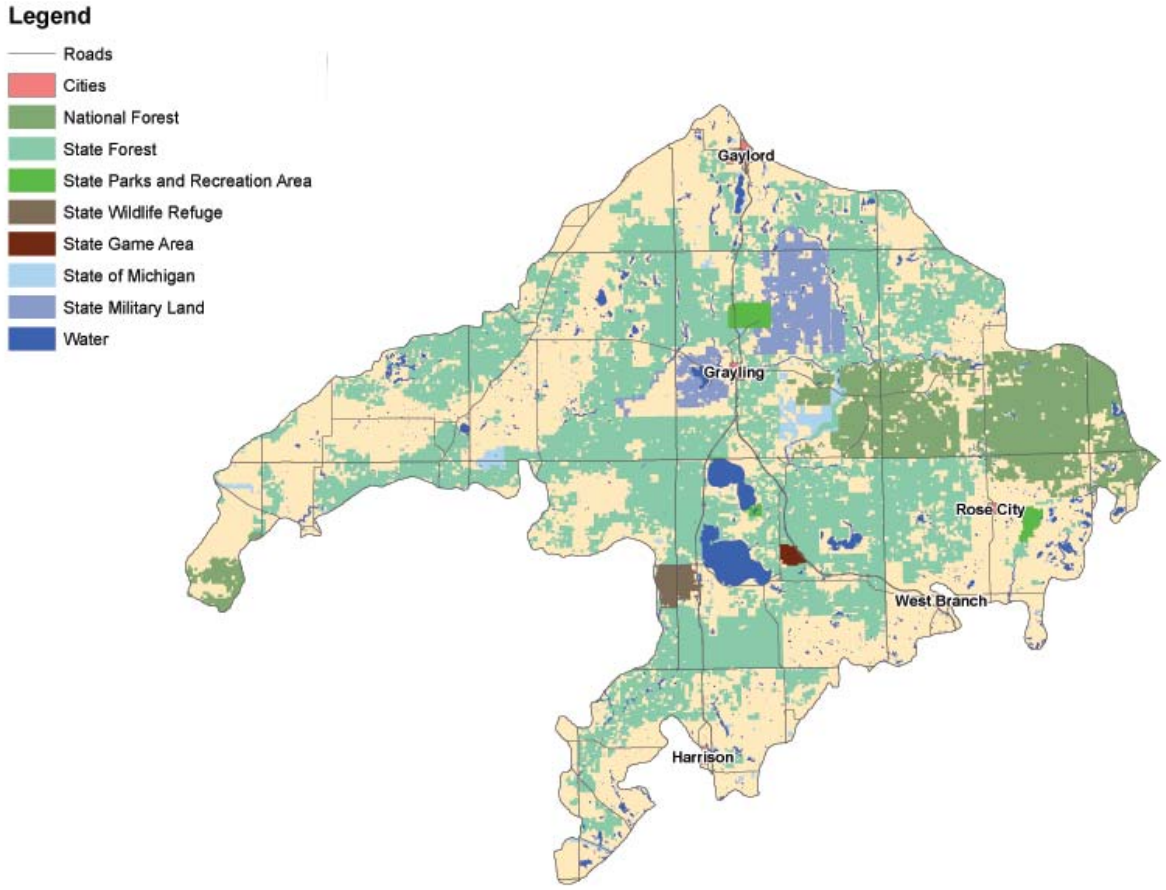

Figure 6. Map of land holdings of federal and state agencies (Michigan Geographic Data Library 2005).

Public Entities

USDA Forest Service

Congress established the USDA Forest Service in 1905 for the purposes of watershed protection, timber production, and conservation. Later Congress passed the Multiple Use Sustained Yield Act of 1960, which required the Forest Service to manage their lands for multiple use and sustained yield of products and services of the forests. The National Forest Management Act of 1976 required that management plans were developed with public input for each forest. Years of controversy and legal challenges regarding the Forest Service's timber harvesting practices led to a major shift in priorities and reductions in timber harvests in the early 1990s, and the Forest Service formally adopted an ecosystem management approach in 1994.

The majority of the Huron National Forest falls into the Grayling Subdistrict. It was created in 1909 and combined administratively with the Manistee National Forest in 1945. The forests are managed for timber, wildlife, and recreation, and the endangered Kirtland's warbler is a major priority for the Huron National Forest. Since 1986, the Huron-Manistee National Forests have been operating under the 1986 Forest Plan. They are currently undergoing a Forest Plan revision process, however, to incorporate changes in national management guidelines and the availability of new information regarding forest management (USDA Forest Service 2003). In addition, the National Forest Management Act of 1976 requires that Forest Plans be revised every 10 to 15 years. Many existing areas are locked into management for the warbler already, and it will be very difficult to change practices in these existing areas because the warbler is

completely dependent on them. However, the USDA Forest Service is hoping for more flexibility in their new Forest Plan to experiment with alternative habitat arrangements outside of designated Kirtland's Warbler Management Areas, since the species' population has increased beyond the minimum goal. See the section on the Kirtland's warbler below for more information on its current management.

A traditional management priority for the USDA Forest Service is fire suppression. Years of successfully preventing wildfires have led to a buildup in fuels and drastic changes in species composition in many areas of the Grayling Subdistrict. In their latest Forest Plan revision the USDA Forest Service has recognized that fire is critical to the health of much of the forest. The USDA Forest Service is trying to find ways to combine the multiple benefits of fire, including fuels reduction and wildlife habitat maintenance and restoration (USDA Forest Service 2005e). However, difficult barriers exist to increasing the use of prescribed fire in the forests. Primary barriers include the interspersion of private lands throughout the forest and public attitudes towards fire.

The USDA Forest Service is becoming more open to managing for barrens and other community types that generate less timber, partly due to the recent shift in priorities away from timber and towards other values. However, they still face multiple barriers to carrying out ecosystem restoration. For instance, they are bound by legal requirements and must go through National Environmental Protection Act (NEPA) procedures whenever they propose to change anything on the forest. They must reconcile their biologists' recommendations with leadership's possibly conflicting goals. Another constraint involves economics and timber sales—there are annual limits on the amount of timber that can be harvested from the entire forest, so they must balance the amounts of restoration with other planned activities. Administering timber sales is also expensive and time consuming—funds are necessary to produce timber, which in turn will generate more funds. Restoration, however, is a long, continuous process that will likely require more funding than it will generate. On the positive side, creating new jack pine barrens would produce more timber initially and would also help the Huron-Manistee National Forests meet their wildlife management objectives. The Forest Service faces a final barrier to restoring target community types in the lack of scientific research and examples of what constitutes a "quality" jack pine barren, for example (USDA Forest Service 2005e).

MI Department of Natural Resources

The Michigan Department of Conservation was created by the state legislature in 1921 to manage and protect the state's natural resources. Its name was changed to the Department of Natural Resources in 1968 to reflect broader responsibilities and society's growing demand for resources. Today, the MI DNR is "committed to the conservation, protection, management, use and enjoyment of the State's natural resources for current and future generations" (MI DNR 2006a). The MI DNR has several divisions—such as Forest, Mineral and Fire Management (FMFM), Wildlife, Parks and Recreation, Fisheries, and Law Enforcement—that are responsible for a multitude of issues ranging from hunting, fishing and off-road vehicle (ORV) licenses and campgrounds to oil and gas leasing, timber sales, wildlife management, and biodiversity conservation. In 1995, the governor transferred some regulatory, permitting, and enforcement duties to the Department of Environmental Quality (MI DNR 2006a).

The MI DNR operates under the direction of the Michigan Natural Resources Commission (NRC), whose seven members are appointed by the governor and serve four-year terms. The

NRC holds monthly public meetings and establishes general MI DNR policies. The MI DNR also has several advisory committees to assist them in identifying issues and developing policies and to serve as liaisons between public land users and the MI DNR. Such groups include the Forest Management Advisory Committee, the ORV Advisory Board, the Snowmobile Advisory Committee, the Citizens Committee for State Parks, and the Waterways Commission.

The MI DNR formally adopted an ecosystem management approach in 1996. Key principles of the MI DNR's ecosystem-based management include partnerships and citizen participation and a science-based approach, long-term view, and comprehensive perspective (MI DNR 2005f). They have been slow to truly apply this approach when making management decisions because the way the department is compartmentalized is not conducive to management based on ecosystem boundaries (MI DNR 2005b). The FMFM division's jurisdiction is divided into eight Forest Management Units (FMUs) in the northern Lower Peninsula. The Grayling Subdistrict encompasses much of the Grayling, Roscommon, and Traverse City FMUs and parts of the Cadillac, Gaylord, and Gladwin units. Despite such administrative difficulties, the MI DNR has initiated ecoregional planning processes and is currently soliciting public input for the Northern Lower Peninsula Ecosystem Management Plan (MI DNR 2005c) (figure 7).

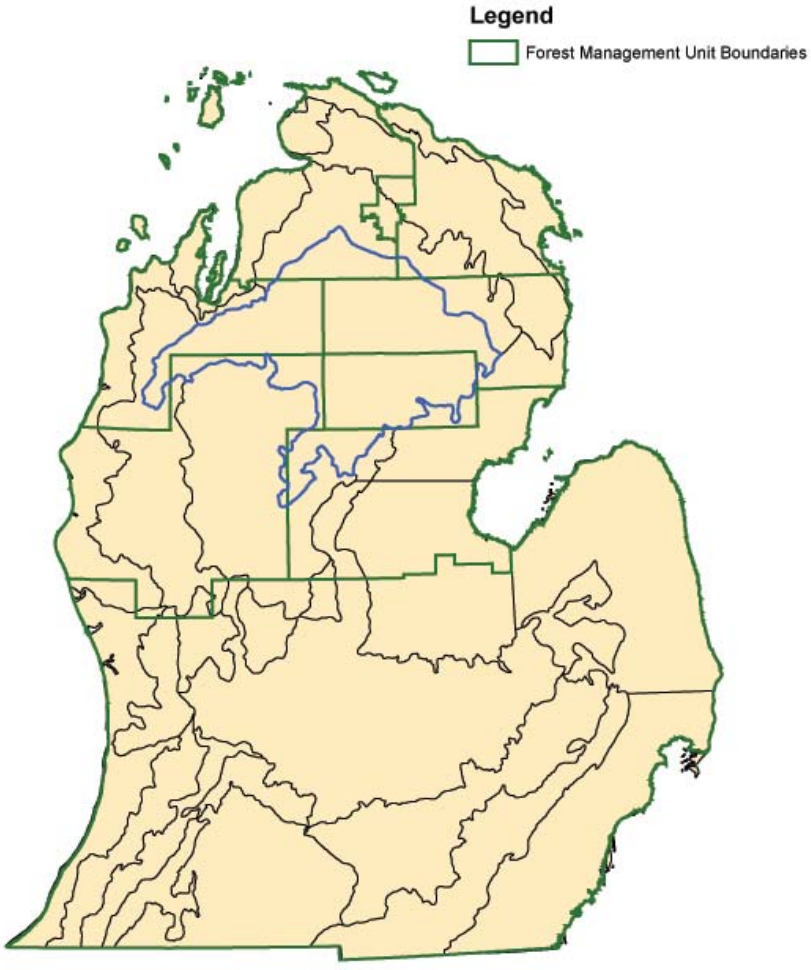

Figure 7. Map of forest management units of the Michigan Department of Natural Resources (Michigan Geographic Data Library 2005).

Public Act 125 of 2004, "Sustainable Forestry on State Forest Lands," calls for the MI DNR to obtain third-party certification of state forests beginning in 2006 (MI DNR 2006b). The Forest Stewardship Council (FSC) and the Sustainable Forestry Initiative (SFI) both awarded certification to the state in January 2006. Sample sections will be audited every year, and a comprehensive audit will take place every five years (Dettloff 2006). Certification is based on environmental, social, and economic criteria including protection of water resources, biodiversity, soil productivity, and workers' rights.

As with the Forest Service, the Kirtland's warbler has been a high management priority for the MI DNR. They have worked closely with the Forest Service, Camp Grayling, and the U.S. Fish and Wildlife Service to coordinate management for the warbler. The MI DNR also hopes to try different management techniques, including prescribed fire, now that the warblers have recovered beyond the minimum number required in their Recovery Plan (MI DNR 2005b).

Fire suppression is another major responsibility of the MI DNR. They carry out some prescribed burning in a few state parks but otherwise face many hurdles to increasing their use of fire in forest and habitat management. Although public attitudes have been changing as our understanding of the natural role of fire has improved, people are still very sensitive about fire, and suppression remains the top priority for public agencies.

One management problem faced by the MI DNR is a lack of funding for scientific surveys of species and habitats. Their approach to data collection is inconsistent, and it is difficult for them to make decisions without accurate, up-to-date information. The Michigan Natural Features Inventory assists with such tasks but depends on funding from the state and other clients to carry out surveys.

One important conservation program jointly funded by the MI DNR and U.S. Fish and Wildlife Service is the Landowner Incentive Program (LIP). The program provides private landowners with advice, management plans, and technical and financial assistance to enhance, restore, and protect habitats for species at risk (MI DNR 2004a). In the northern Lower Peninsula, the program focuses on barrens and other jack pine habitats, and the management priority is to implement prescribed burns. Currently, they are targeting landowners with property of at least 15 to 20 acres. The LIP faces challenges related to convincing landowners to use prescribed fire on their property and to the high cost of hiring contractors to carry out prescribed burns (MI DNR 2005b). Other challenges include high rates of absentee landowners, making it difficult for staff to communicate with them, and shrinking lot sizes, which reduce the size of potential restoration and prescribed burn sites. The LIP is considered a success despite these challenges—they have burned hundreds of acres, and additional burns are planned for upcoming seasons (figure 8). The MI DNR's LIP staff positions were made permanent in 2005, although they will still need to apply for a grant periodically to fund the program (Piccolo 2005). Currently, they have acquired funding through 2007.

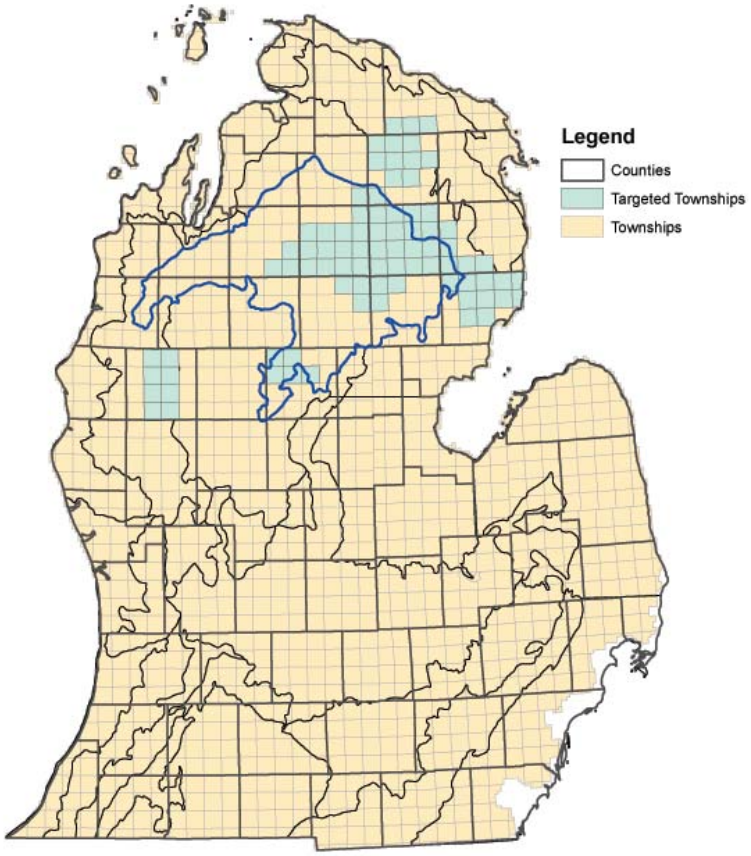

Figure 8. Map showing the locations of the targeted townships in the Landowner Incentive Program (LIP) in northern Lower Michigan (MI DNR 2005e).

Michigan National Guard—Camp Grayling Military Reservation

Most of the 147,000 acre Camp Grayling Military Reservation (Camp Grayling) is managed by the DNR and leased to the Michigan Department of Military Affairs (DMA). Lands within the Multipurpose Range Complex (MPRC) are managed by the DMA. All land outside the MPRC is open to the public for recreational use except during active military training (Kost et al. 2000). Camp Grayling has an Integrated Natural Resource Plan to guide their land management practices, which include using native species for restoration work. Prescribed fire is not used for ecological purposes in the area, but they do carry out burns to reduce fuel loads where fire will be used in training (Jacobs 2005).

A plan exists to restore and maintain jack pine barrens in an area within Camp Grayling. Produced by the Michigan Natural Features Inventory (MNFI) in 2000, the *North Camp Grayling Pine Barrens Management Plan* is "intended to serve as a catalyst and guide for creating and maintaining a functioning pine barrens ecosystem" (Kost et al. 2000). The proposed management area covers 5,120 acres and is currently managed for military training, wildlife habitat, forest products, and public recreation. The plan recommends reintroducing fire, replanting red and white pine, limiting soil disturbances, and preventing the spread of spotted knapweed. The DNR will be responsible for its implementation. However, the plan remains on hold due to the possibility that Kirtland's warblers will move into the area as restoration progresses, which would disrupt military training activities. The Army National Guard hopes to obtain an agreement to exempt their activities from the Endangered Species Act should warblers move into the

area. In this case, the birds would not be counted as part of the Kirtland's warbler population and would be considered superfluous (Kost et al. 2000).

United States Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) is "responsible for conserving, protecting and enhancing fish, wildlife and plants and their habitats for the continuing benefit of the American people" (USFWS 2006). Their primary involvement in the Grayling Subdistrict involves the Kirtland's warbler, eastern massasauga rattlesnake, and other threatened or endangered species (or candidates for listing). Currently the MI DNR and USFWS are creating a candidate conservation agreement with assurances (CCA) regarding the eastern massasauga. Landowners who sign on to the agreement can get funding and aid for managing their land as ideal habitat for the snakes over at least five years.

The Kirtland's Warbler Recovery Effort

The Kirtland's warbler is species of bird that nests in northern Lower Michigan and winters in the Bahamas. It experienced a dramatic decline in the mid-20th century: in 1971, a decennial census discovered only 201 singing male Kirtland's warblers, representing a total population of approximately 400 birds—a 60% decrease from the 1961 census (Byelich et al. 1985). In response to this decline, the Kirtland's Warbler Recovery Team was formed and subsequently designed and implemented the *Kirtland's Warbler Recovery Plan.* The primary objective of the recovery plan is to reestablish a self-sustaining population of 1,000 pairs. In 2001, the Kirtland's warbler census recorded 1,085 signing males, marking a major success for the Recovery Team's effort (Olsen 2002). This was a large-scale coordinated effort in single-species management that was very successful. The recovery of the Kirtland's warbler occurred because of the intensive ecological management and restoration effort undertaken by the USDA Forest Service, the MI DNR, and the U.S. Fish and Wildlife Service.

Michigan Natural Features Inventory

The Michigan Natural Features Inventory (MNFI) is comprised of teams of scientists who "collect information about Michigan's native plants, animals, aquatic animals and natural ecosystems" (MNFI 2006b). A nonprofit organization based in Lansing and affiliated with Michigan State University Extension, their work is primarily funded through contracts and grants. They provide information as well as mapping and planning services. The mission of the MNFI is "to actively contribute to decisions that impact the conservation of biological and ecological diversity by collecting, analyzing, and communicating information about rare and declining plants and animals, and the array of natural communities and ecosystems native to Michigan" (MNFI 2006b). MNFI is a member of NatureServe, an international network of biological inventories.

Private Entities

Private Landowners

Approximately 75% of the land in the northern Lower Peninsula is privately owned (MI DNR 2004a). Although some counties in the Grayling Subdistrict contain a relatively high percentage of public lands—particularly Crawford, Kalkaska, Roscommon, and Oscoda—private landowners are still an important group in the region. Private lands in the Grayling Subdistrict are often located next to or within public lands, which can cause problems for public land

managers. Michigan also has very high proportions of seasonal homes in the northern Lower and Upper Peninsulas. These homes add further complexity to the management issues that result from private lands being interspersed in public lands.

One problem that results from private lands' proximity to public lands—especially forests—is the increased risk of homes, property, and people being damaged by fire and the corresponding increased cost of protecting them from fire. In addition, public perception of fire remains largely negative despite progress through education about the natural role of fire (USDA Forest Service 2005d). Private landowners' property and negative attitudes towards fire clearly have implications for the future use of fire for ecosystem management and restoration. Landowners living near public forests are also less tolerant of management activities near their land, such as harvesting. They may require the agency to leave a visual buffer of trees or even deny them access for crossing private property (MI DNR 2005h). They want to see trees around their property, which could be a barrier to future barrens restoration efforts on or near private lands.

Growth in new seasonal homes has decreased since the booms of the 1970s and 1980s, but conversion of forest to development continues to be an issue in the Grayling Subdistrict. According to the 1990 Census of Housing cited in Stynes et al. (1997), seasonal homes make up 53% and 56% of housing units in Roscommon and Oscoda counties, respectively. Other counties in the Subdistrict contain proportions of one-third to one-half seasonal homes. Even many of the homes classified as permanent are actually unoccupied for part of the year (Stynes 2006). Seasonal homes usually occur at the edges of state and national forests (especially in the subdistrict) or next to lakes and streams. More of these inland homes are "rustic" when compared with those along the Great Lakes shorelines, but an increasing number of them are considered "upscale," since many existing homes have been expanded and upgraded. Lot sizes have been decreasing and landowners are less likely to have forests or produce timber. There are also more planned developments now than before, especially golf and skiing communities. And recently, more homes have been converted to permanent homes as their owners retire, leading to an increase in the region's permanent residents (Stynes 2006).

Seasonal homeowners tend to have higher incomes than the general population and especially local residents. They also tend to be well-educated and more likely to support environmental protection. They are particularly apt to oppose new development, especially near their homes, once they own a home in the area (Stynes 2006). Seasonal homeowners are less concerned with local economic development and job creation because they do not depend on local jobs for their income, so they are again less likely to support new development in the area (Stynes 2006). However, the absentee nature of seasonal homeowners poses a barrier to working with them to implement land management programs (figure 9).

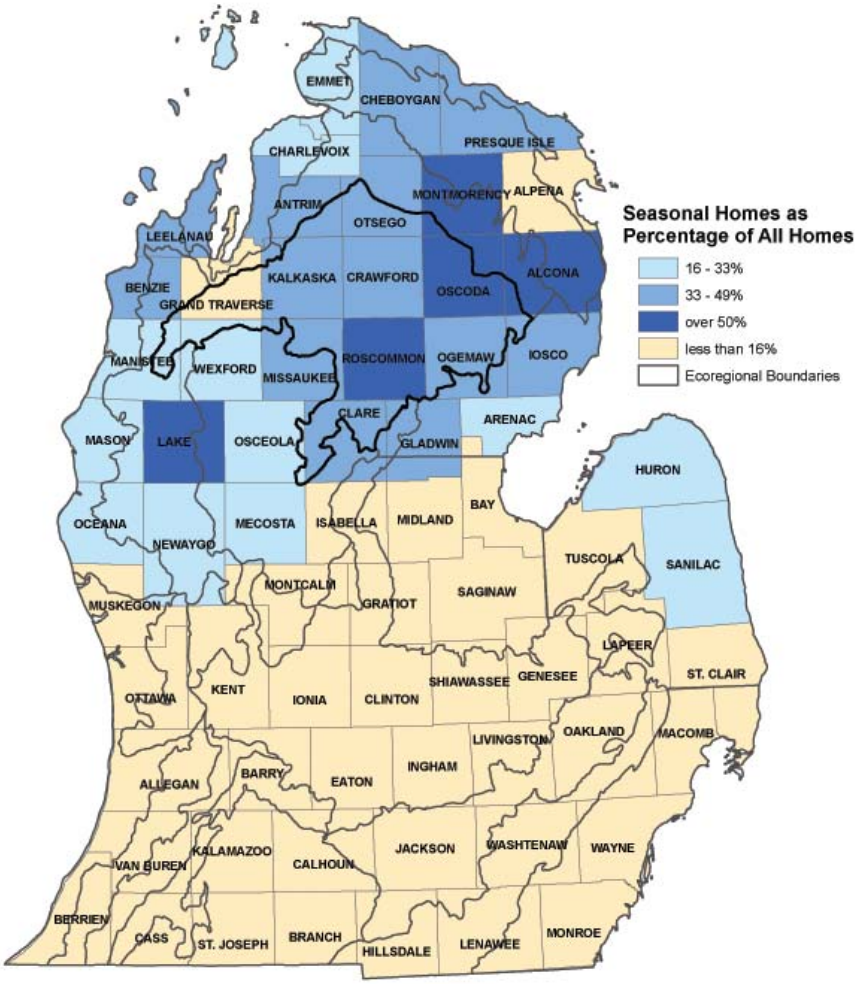

Figure 9. Map of the percentage of seasnonal homes in the Lower Peninsula (Stynes et al. 1997; Michigan Geographic Data Library 2005).

Interest Groups

Off-Road Vehicle Users

ORV use is a popular form of recreation in Michigan, both as a trail riding activity and as a mode of transportation for hunters and fishers. There are currently 3,100 miles of designated ORV trail in the state, 73% of which fall on state forest land. In the 2003–2004 year, there were 174,651 licensed ORVs in Michigan, a 124% increase since licensing began in 1994–1995 (Nelson 2005b). ORV users appear to be well organized and they actively participate in public meetings regarding land management. In general, these users desire additional legal places to ride ORVs, as well as improved maintenance and signage of existing trails. They have also expressed concerns about reductions in trail mileage and challenge level due to timber harvests (Nelson 2005b).

The MI DNR holds primary management responsibility for ORVs, and the USDA Forest Service follows DNR regulations on the Huron-Manistee National Forest. The DNR issues licenses and administers the ORV Trail Improvement Fund. At $16.25 per license, $2.8 million in revenue was generated for the ORV Trail Improvement Fund in 2003–2004 (Nelson 2005b). This fund is distributed primarily between trail maintenance and development (50%), environmental damage restoration (12.5%), and law enforcement (31.25%). Much of the fund's work

is carried out by grant recipients—usually ORV user groups—and county sheriffs. The DNR is also in charge of the ORV safety education and training program.

DNR priorities for ORV damage restoration include reducing or eliminating erosion into bodies of water, restoring damage in roadless areas and natural or scenic river corridors, and restoring damage to aesthetically sensitive areas (Nelson 2005a). However, participants at a recent restoration grant recipient workshop have expressed concern about the "slow pace of restoration" (Nelson 2005a). They highlighted the "need for a better system to identify ORV damage to public lands, the need to use practical soil erosion and re-vegetation techniques and a streamlined grant process, …" as well as the "need to involve a wider variety of organizations in damage restoration" (Nelson 2005a).

Michigan Audubon Society

The Michigan Audubon Society was founded in 1904 and became a chapter of the National Audubon Society in 1972. Its members engage in public education, support research, maintain sanctuaries, and promote conservation-oriented practices and policies in order to foster the preservation of native animals and plants (Michigan Audubon Society 2005). Members of the 43 local chapters go on field trips and tours and many are active in local conservation efforts. As their primary focus is on birds, the Kirtland's warbler is clearly important to the Michigan Audubon Society.

Sportspersons

Michigan has large numbers of registered hunters and fishermen. The Michigan United Conservation Clubs (MUCC), an important sportspersons' umbrella group, was founded in 1937 by a coalition of 35 outdoor clubs with the mission of "uniting citizens to conserve Michigan's natural resources and protect our outdoor heritage" (Michigan United Conservation Clubs 2003). MUCC works to conserve Michigan's wildlife, fisheries, waters, forests, air, and soils by providing information, education and advocacy (Michigan United Conservation Clubs 2003). Much of their work is related to hunting and fishing. The organization currently has over 100,000 members in the state and has over 500 affiliated clubs.

Tribes

Our research has not indicated any recent tribal involvement in land management within the Grayling Subdistrict. There are no reservations or facilities within the project region. Before European settlement, the Chippewa and Ottawa tribes occupied parts of northern Lower Michigan (US EPA 2000).

Part II: The Grayling Subdistrict

Chapter 5: Conservation Targets

Overview

The Grayling Subdistrict contains several unique vegetative communities and many rare and endangered species of conservation concern both statewide and globally. In this chapter we describe the conservation targets we have chosen for our project, which represent some of the most rare and endemic communities and species of the Grayling Subdistrict. A few species occur in more than one community type, so they are only described once, in the community that is listed first.

Our target communities and species were chosen in part based on their global and state ranking as assigned by NatureServe and the Michigan Natural Features Inventory (MNFI). As described in chapter 4, MNFI is part of the NatureServe natural heritage network, which aims to "provide the scientific information and tools needed to guide effective conservation action." As a component of this mission, NatureServe and natural heritage programs conduct regular status assessments or evaluations of the relative imperilment of species and natural communities. Based on these assessments and the opinion of independent experts, NatureServe (2006a) and MNFI (2003) then assign each species and natural community a global (G) and state (S) conservation status rank. For plant and animal species the ranking provides an estimate of the species' risk of extinction, while for natural communities the rank provides an estimate of the risk of elimination. The conservation status ranks range from one to five, with one representing the most imperiled species and five representing the most secure species. For example, the federally endangered Kirtland's warbler *(Dendroica kirtlandii)* has been ranked as G1/S1, or critically imperiled due to rarity on both global and state scales. NatureServe (2006a) currently does not assign conservation status ranks for ecological systems. Specific information on the definition of the global (G) and state (S) ranks is provided in appendix A.

Jack Pine Barrens (G2/S2)

"Jack pine barren" is a community type name given to a generic group of fire-prone ecosystems typically characterized by outwash plain topography and dry, sandy soil. They occur in Lower Michigan, Wisconsin, Minnesota, and eastern Ontario. Historically jack pine barrens were distributed across this range with major concentrations in the High Plains District of Michigan and in north-central Wisconsin (Comer 1996; Cohen 2005). Scattered jack pine barrens were also present in Michigan's Upper Peninsula and along the upper Mississippi and St. Croix Rivers in Wisconsin and Minnesota (Cohen 2005).

The jack pine barren community type is endemic to dry, nutrient-poor ecosystems in glacial outwash plains, glacial lakebeds, sandy lake plain, ice contact terrain, and sandy riverine terraces that are often underlaid by well-sorted, course-textured sandy soils with low water retaining capacity (Cohen 2005; Comer 1996). The lack of natural firebreaks on flat or gently rolling topography allows for broad-scale fires to carry across these landforms. In areas of rolling topography, jack pine barrens may be found in depressions that collect cold air, forming frost pockets (Comer 1996).

The vegetative community of jack pine barrens is dominated by grasses, forbs, shrubs, and infrequent, scattered trees (Kost et al. 2000; Comer 1996). Jack pine *(Pinus banksiana)* is the dominant tree in the sparse overstory of this community and is very often associated with northern pin oak *(Quercus ellipsoidalis)*. Historically there may have been an emergent canopy of open grown red pine *(Pinus resinosa).* Red and white pines *(Pinus strobus)* were sub-dominants in jack pine barrens but a majority of these large trees were removed in the mid-late 1800s

logging boom (Cohen 2005). Black cherry *(Prunus serotina),* and bigtooth and trembling aspens *(Populus grandidentata, P. tremuloides)* often occur in jack pine barrens as young or stunted trees. Common shrubs include low sweet blueberry *(Vaccinium angustifolium)*, sweet fern *(Comptonia peregrina)*, sand cherry *(Prunus pumila)*, prairie willow *(Salix humilis)*, hazelnut *(Corylus spp.)*, and bearberry *(Arctostaphylos uva-ursi)*. The herbaceous vegetation is dominated by poverty grass *(Danthonia spicata)*, little bluestem *(Schizachyrium scoparium)*, and Pennsylvania sedge *(Carex pensylvanica).* Other common species of jack pine barrens include big bluestem *(Andropogon gerardii)*, hair grass *(Deschampsia flexuosa)*, birdfoot violet *(Viola pedata)*, prairie heart-leaved aster *(Aster oolentangiensis)*, June grass *(Koeleria macrantha)*, rough blazing star *(Liatris aspera)*, prairie cinquefoil *(Potentilla arguta)*, and needle grass *(Stipa spartea).*

Frequent fires, subfreezing temperatures, and drought conditions often combine to prevent the establishment of woody vegetation, therefore creating and maintaining woodland or open conditions that characterize jack pine barrens. This open structure is a crucial component of the system and key to the life cycle of many jack pine barrens species. Estimates of the historic fire return interval for jack pine systems vary depending on the scale and geographic location of the study (Cohen 2005). Simard and Blank examined the fire scars of red pines killed in the 1980 Mack Lake fire to determine an approximate fire interval for northern Lower Michigan over the last 160 years (1982). They report a mean interval of 25 years for an individual tree and a mean interval of 19 years for a 5-acre area. Overall, Simard and Blank (1982) estimate a fire frequency for the Mack Lake area to have ranged between 13 and 41 years. Whitney (1986) estimated that in northern Lower Michigan the average return time was 80 years for canopy replacing fires and 25 years for surface fires. This coincides with fire intervals reported by Heinselman (1981) in Minnesota who estimated fire returns for jack pine barrens to be 50-100 years with moderate surface fires occurring every 20−40 years (as reported in Cohen 2005). The draft report of the Rapid Assessment Reference Condition Model estimates the average fire interval to be 41 years for stand replacing fires, 36 for mixed fires, 4 years for surface fires, and 3 years for all fires in jack pine barrens (Cohen 2005). In general most estimates of fire return intervals are thought to be conservative as evidence of light to moderate surface fires are difficult to detect. Nevertheless, low-level fires are important in reducing fuel concentrations and regulating seedling composition and distribution (Barnes et al. 1988).

The Rapid Assessment Reference Condition Model also estimates that historic fires in jack pine barrens averaged 200 acres, with a minimum size of 100 acres and a maximum of 1000 acres. It is most likely that fires in the Grayling Subdistrict were highly variable, patchy, and may have carried across several thousand acres. The 1980 Mack Lake fire burned nearly 24,000 acres in one day (Simard and Blank 1982). In presettlement times, this combination of frequent fire and cold frost pocket conditions created a shifting mosaic of jack pine-dominated vegetation across the landscape of the Grayling Subdistrict (Kost et al. 2000).

According to Comer et al. (1995) approximately 270,000 acres of pine barrens were historically present in Michigan. About 210,000 were distributed across the Lower Peninsula and primarily concentrated in the High Plains District. In Crawford County there were an estimated 55,000 acres, Iosco County 33,000 acres, and Oscoda County 32,000 acres. In total an estimated 120,000 acres of historic barrens were recorded in the Grayling Subdistrict. Today, the Michigan Natural Features Inventory estimates that there are fewer than five high quality examples in the state, totaling only a few hundred acres (Comer 1996).

Species of Jack Pine Barrens

In the Grayling Subdistrict, jack pine barrens provide habitat for numerous rare and endemic plant and animal species. This includes several rare insects such as the dusted skipper *(Atrytonopsis hianna),* Henry's elfin *(Incisalia irus),* blazing star borer *(Papaipema beeriana),* red-legged spittlebug *(Prosapia ignipectus)*, grizzled skipper *(Pyrgus centaureae wyandot)* and doll's merolonche *(Merolonche dolli).* The prairie *(Dendroica discolor)* and Kirtland's warblers *(Dendroica kirtlandii)* have also been associated with jack pine barrens habitat in the region. Michigan's jack pine barrens also support several rare plant species such as rough fescue *(Festuca scabrella),* pale agoseris *(Agoseris glauca),* Hill's thistle *(Cirsium hillii)*, and Alleghany plum *(Prunus alleghaniensis* var. *davisii).* More information on these species is presented below.

Plants

Alleghany Plum (Prunus alleghaniensis var. davisii) (G4/S2)

Prunus alleghaniensis var. *davisii* is a widespread species distributed from central Pennsylvania to western Michigan to West Virginia with local populations in Connecticut, Virginia, and eastern Tennessee (Higman and Penskar 1996d). The species is currently considered a state species of special concern. NatureServe (2006b) ranks *Prunus alleghaniensis* as G4, indicating that this plant is currently considered secure across its species-wide range. Voss (1985) describes this species as divided into two distinct varieties: var. *alleghaniensis,* which represents the Appalachian populations of the species, and var. *davisii,* which represents the disjunct, endemic populations only found in Michigan. Approximately 40 occurrences are documented in Michigan (Higman and Penskar 1996d). The largest concentration of *Prunus alleghaniensis* var. *davisii* is in the Grayling Subdistrict, specifically Oscoda and Crawford Counties (MNFI 2005b). In addition, there are approximately 15 documented occurrences in the western Lower Peninsula (Manistee and Newaygo Counties) and three documented occurrences in southern Lenawee County (Higman and Penskar 1996d).

In the western Lower Peninsula, the plant is found in old fields and remnant dry sand prairies. In the Grayling Subdistrict, particularly Montmorency, Crawford, Oscoda, Roscommon, and Ogemaw counties, the species occurs in remnant openings in jack pine barrens. The soils of both locations are somewhat excessively drained, acidic Grayling sands (Higman and Penskar 1996d; Taylor 1990). Whereas the majority of the documented occurrences of *Prunus alleghaniensis* var. *davisii* are along roadsides, a large genetically diverse stand occurs on a broad outwash plain in northern Oscoda County, known locally as the "frost pocket." This site is currently owned by the Michigan Department of Natural Resources and is managed as a pine barrens (MI DNR 2005b).

Hill's Thistle (Cirsium hillii) (G3/S2)

Cirsium hillii is a Great Lakes species ranging from southern Ontario through Michigan, Wisconsin, Minnesota, Iowa, Illinois, and Indiana (Penskar 1997). The largest number of documented occurrences is in Michigan, 130 total. Within the state, *Cirsium hillii* is found within three primary areas: the Shakey Lakes oak savanna area of Menomiee County in the Upper Peninsula, the alvar habitat on Drummond Island, and the jack pine barrens of the Grayling region (Higman and Penskar 1996b). The stronghold of the species is in the Grayling Subdistrict, particularly Crawford county.

Throughout its range, *Cirsium hillii* is found on dry, sandy, gravelly soils of prairies, jack pine barrens, oak savannas, and open woods. In the Grayling Subdistrict, *Cirsium hillii* is found in open, fire-prone areas with common associates such as jack pine, Pennsylvania sedge, rough fescue, cooper's milk-vetch *(Astragalus neglectus),* and pale agoseris (Higman and Penskar 1996b).

In the *Rangewide Status Assessment of Cirsium hillii (Canby) Fern*, Penskar (1997) notes that biologists from the Forest Service, MI DNR, and MNFI have observed Hill's thistle as "relatively common" over much of the pine barrens landscape. The species is found in a variety of disturbed pine plains, oak-pine barrens, pipeline and railroad corridors, road rights-of way and in red pine plantations. In addition, some agency staff noted that Hill's thistle may benefit from, or at least be resistant to, jack pine and other timber management activities (Penskar 1997).

Cirsium hillii is a perennial thistle with a deep, hollowed, and thickened taproot. The plant blooms from June through August and will live for two to five years (Higman and Penskar 1996b). The plant flowers two to three years after establishment. *Cirsium hillii* is an abundant seed producer although its flowers and seeds are vulnerable to insects and fungi. Its seeds are wind dispersed, but the plant can also reproduce vegetatively by adventitious buds that form on the lateral roots (Higman and Penskar 1996b).

Pale Agoseris (Agoseris glauca) (G4G5/S2)

Agoseris glauca is a widespread species in western North America. Its range is centered in the Great Plains, yet the plant can be found from Alaska to Ontario and south along the Rockies into Arizona (Higman and Penskar 1996a). The populations of *Agoseris glauca* in Michigan represent a disjunction of approximately 600 miles from the species' main range. Within Michigan, the species only occurs within the Grayling Subdistrict, specifically Otsego, Crawford, Oscoda, and Montmorency counties. The plant is often found in association with another more western species, rough fescue. It occurs in dry grassy openings often associated with remnant savannas and jack pine barrens (Higman and Penskar 1996a).

In his 1979 survey of *Agoseris glauca* in the Grayling Subdistrict of Michigan, Mustard (1982) surveyed 20 populations of the species and found it typically growing in "xeric, grassy clearings in the jack pine association." All localities Mustard surveyed occurred on glacial outwash and did not show evidence of direct disturbance within the last 15 years. The plant occurs on well drained Grayling and Rubicon sands with a pH ranging from about 5 to 7.

Agoseris glauca is a perennial species that develops from a deep tap-root (Mustard 1982). Although the seeds of pale agoseris are wind dispersed, the relative lack of genetic diversity within the population suggests that self-fertilization may be common (Higman and Penskar 1996a).

Rough Fescue (Festuca scabrella) (G5/S3)

Festuca scabrella is a widespread species in western North America. It ranges from North Dakota and Colorado to Alaska (Higman and Penskar 1996c). In the east, the species is found in isolated populations of Newfoundland, Quebec, Ontario, and Michigan (NatureServe 2006b). Within Michigan, the species only occurs within the Grayling Subdistrict, specifically Otsego, Crawford, Oscoda, and Montmorency counties. The plant is commonly associated with

another western disjunct, pale agoseris, in openings of sandy jack pine barrens. It is often found in openings created by recent logging or fire. It is thought to benefit from Kirtland's warbler management that creates savanna-like openings (Higman and Penskar 1996c).

Festuca scabrella is a perennial, cool-season grass that develops from short rhizomes and forms dense clumps. As a cool-season grass, the plant completes most of its growth prior to midsummer.

Animals

Blazing Star Borer (Papaipema beeriana) (G3/S1S2)

The blazing star borer is currently considered a state species of special concern. It has been documented in a series of disjunct populations in Midwestern states such as Iowa, Illinois, Indiana, Ohio, Wisconsin, and Michigan. In Michigan, the species has been recorded at 12 sites, mostly in the southern Lower Michigan. Within the Grayling Subdistrict, MNFI has documented two occurrences in Otsego County.

The blazing star borer has been found in a variety of vegetation types including lakeplain prairie, prairie fens, sand prairie, and barrens, provided these habitats contain the species' larval host plant—blazing star/snakeroot *(Liatris spp.)*. Larvae bore a hole at the base of the host plant and tunnel into the roots to feed (Cuthrell 1999a). It can be found in its larval and pupal stages from July through October and is active late at night. The adults are associated with several common prairie species such as big bluestem, Indian grass (*Sorghastrum nutans*), common mountain mint (*Pycnanthemum virginianum*), tall coreopsis (*Coreopsis tripteris*), Ohio goldenrod (*Solidago ohioensis*), Culver's root (*Veronicastrum virginicum*), and switchgrass (*Panicum virgatum*) (Cuthrell 1999a).

Doll's Merolonche (Merolonche dolli) (G3/S1S2)

Merolonche dolli is a moth species that is poorly understood and likely widely overlooked (NatureServe 2006b). The species is known from three main regions – the Appalachians from southeastern New York to northern Georgia: the New Jersey Pine Barrens; and the Great Lakes region from Michigan to Minnesota. The species may be more widespread, especially in the Great Lakes, yet adults are very difficult to locate even when they may be locally abundant. In the Grayling Subdistrict the species has four documented occurrences in Otsego and Roscommon counties (MNFI 2005b). The habitat of this moth is not particularly clear, yet throughout its range the species has been noted in bogs, pine-oak barrens, Great Lakes oak savannas, or oak barrens. Larvae of *Merolonche dolli* have been found to feed on oaks and ericaceous shrubs, while the food plant of adults is unknown. The moth does not have an underground stage as the cocoons are spun in leaf litter, making the species potentially vulnerable to fire (NatureServe 2006b).

Dusted Skipper (Atrytonopsis hianna) (G4G5/S2)

Atrytonopsis hianna is a small, brown-gray butterfly that ranges across the United States and Canada from the Rocky Mountains to the Atlantic Coast (Struttmann 2006). In Michigan, the species has a disjunct distribution with occurrences or populations scattered across 15 counties in the Lower Peninsula. In the Grayling Subdistrict, 23 occurrences have been documented in

Crawford, Kalkaska, Oscoda, and Otsego counties (MNFI 2005b). The Forest Service reports that there is no historical documentation of the dusted skipper in the Huron-Manistee National Forest. Yet, based on the drastic loss of its habitat in the region it is presumed that the species was once much more widespread and common than its current distribution (USDA Forest Service 2005a). The species is considered threatened in Michigan.

Although the *Atrytonopsis hianna* has a widespread distribution, it is often found in localized, patchy colonies. The habitat of the dusted skipper is characterized by open dry fields, woodlands, barrens, and prairies. The species is also known to colonize burns quickly (eNature 2005). Today, the species can be found in old fields, airports, road and utility rights-of-way, pine barrens, and savanna remnants (NatureServe 2006b).

The species overwinters in a larval stage and flight patterns in Michigan are from late May until late June. The larvae live and feed mostly on big and little bluestem and common prairie grasses, while the adults feed on a variety of other plants such as blackberry *(Rubus spp*), cinquefoil *(Potentilla spp.)*, lupine *(Lupinus spp.)*, vetches *(Astragalus spp)*, and yarrow *(Achillea spp.)* (Struttmann 2006).

Frosted or Henry's Elfin (Callophrys irus or Incisalia irus) (G3/S2S3)

This butterfly ranges from southern New England south to South Carolina and westward to Michigan and northwestern Illinois (Howe 1975). Taxonomically, it is unclear whether this organism is actually two or three species or just a single species with specific varieties associated with different foodplants. Regardless, the species or multiple species are considered globally rare. Historically, it was found in grassy openings, savanna, or pine barrens. Today, the species is found in human-created habitats such as powerline and railroad rights-of-way and roadsides. The elfin feeds on species of false indigo *(Baptisia spp.)* and lupine (NatureServe 2006b). MNFI (2005a) has only documented two occurrences, with the last observed sighting in 1954. Little is known about this species' current distribution or abundance.

Grizzled Skipper (Pyrgus centaureae ssp. wyandot) (G1G2/S1S2)

Pyrgus centaureae ssp. wyandot is a small butterfly with black and white checkering on its wings. It lives in open spaces in depressions near forests, probably in prairie and barrens remnants (Struttmann 2006). It is known to have a conflicting taxonomy: *Pyrgus centaureae* is a northern species of grizzled skipper, ranging across Canada, while *P. wyandot* is found in the Appalachian Mountains. Some consider *wyandot* to be a subspecies, while some consider it a separate species, and Michigan populations may even be considered as separate from both *centaureae* and w*yandot* (NatureServe 2006b). There are six listed occurrences in the Grayling Subdistrict, clustered in Crawford, Oscoda, and Otsego counties (MNFI 2005b). *P. centaureae wyandot* eats the nectar of low sweet blueberry *(Vaccinium angustifolium)*, a common groundcover species in the Grayling Subdistrict. The skipper's larval period is approximately 100 days, and the adults emerge in May (NatureServe 2006b). It is a state species of special concern.

Kirtland's warbler (Dendroica kirtlandii) (G1/S1)

The Kirtland's warbler is a small endangered songbird that is considered the rarest wood warbler in North America (Barnes et al. 1998). The warbler is a ground nester that builds compact nests exclusively in small depressions under jack pine trees in the excessively well drained sandy soil of northern Lower Michigan (Walkinshaw 1983). In addition to supporting jack pine and associated ground vegetation, this excessively well drained soil prevents flooding of the Kirtland's ground nests (Byelich et al. 1985). Each breeding warbler pair requires a large area (minimum of 38 acres) of 5 to 20-year-old jack pines for nesting (USDA Forest Service 2005a). Jack pines of this age are typically between two and six meters tall, which allows sparse ground vegetation such as big and little bluestem, poverty grass, sedges, blueberries, blackberries, sweet fern, bracken fern *(Pteridium aquilinum)*, trailing arbutus *(Epigaea repens)*, and/or wintergreen *(Gaultheria procumbens)* to flourish. The warbler will conceal its nest in this low vegetation in an effort to protect it from predation and parasitism (Walkinshaw 1983). As the jack pines mature to a height greater than 6 meters the lower branches begin to die and the ground cover disappears as the crown of the forest begins to shade the forest floor. This creates unfavorable nesting conditions for the warbler (Evers 1994).

The warbler's ideal habitat of jack pine stands has varying density and multiple openings with dense stands around them (Byelich et al. 1985; Walkinshaw 1983). In the past, warbler habitat was highly dependent on fire for regeneration and creation of patchy stand conditions. Kirtland's warblers generally occupy stands on outwash plain and ice contact physiographic systems, first colonizing sites where jack pines grow quickly but remaining longer in sites where the jack pines grow more slowly because of poor soils or a cold microclimate (Kashian et al. 2003; Walker et al. 2003). The warblers have been shown to move from one area to another over time as the conditions in one place become unfavorable and remain favorable in the other (Kashian and Barnes 2000). Aside from the habitat created by the Mack Lake fire of May 1980, managed jack pine plantations have provided the majority of the warbler's habitat in northern Lower Michigan over the past 30 years. Due to the restricted habitat requirement of the Kirtland's warbler, the species was likely never very abundant or widespread (Byelich et al. 1985).

Kirtland's warblers arrive in Michigan in early May and migrate to the Bahamas in late August (Byelich et al. 1985; USDA Forest Service 2005a; Walkinshaw 1983). In the Bahamas, the bird lives in low, dense vegetation, which is widely spread across many islands (Sykes and Clench 1998). While the vegetation of the islands was greatly altered by human colonization and agriculture in the late 1700s and early 1800s (with some attempts at agriculture continuing today), much of it has reverted back to scrubby plants and native species. Due to the abundant habitat and food source provided by the regeneration of low vegetation, currently the Kirtland's warbler is not restricted in its winter range (Sykes and Clench 1998).

Prairie warbler (Dendroica discolor) (G5/S1)

Dendroica discolor is a neotropical migrant that winters in southern Florida, the Caribbean, and Central and South America. It migrates north to breed and can be found throughout most of the Southeastern United States in the summer months. Overall, the North American Breeding Bird Survey data indicates a 44% decline of prairie warbler populations in North America between 1966 and 1993 and the species is currently listed on the National Audubon Society's Watchlist (Audubon Society 2006). In the Midwest, prairie warbler populations are often dis-

junct and isolated (Cooper 2000). Although the species reaches its northern extent in Michigan, it was once thought to be abundant in the Grayling Subdistrict. It is now scarce in the region and considered endangered in the state. MNFI reports that nesting is probable in Kalkaska, Crawford, and Alcona counties. The prairie warbler prefers to breed in large open areas of shrub/scrub habitat with poor soil and clumps of shrubs. This habitat component is found in dunes/lakeshore communities, fallow fields with scattered trees, young jack pine stands, and pine plantations (Cooper 2000).

Red-legged Spittlebug (Prosapia ignipectus) (G4/S2S3)

Prosapia ignipectus is one of two species of *Prosapia* occurring in the northern United States and Canada (Cuthrell 1999b). It is widespread on sandy areas of the Midwest and southern Ontario, and is concentrated in the Grayling Subdistrict counties of Clare, Crawford, and Otsego (MNFI 2005b). A small (less than one cm) black spittlebug with red markings near the legs, it is in its adult form from mid-July through mid-September (Cuthrell 1999b). It lives and feeds on many grasses and other prairie species in jack pine barrens and prairies. The nymphs produce masses of small bubbles of spittle to hide them as they feed on the grasses, while adults do not produce any spittle.

Dry Sand Prairie (G2G3/S2)

Dry sand prairie is one of the most limited vegetative community type in the Grayling Subdistrict but also one of the most unique in terms of flora and fauna. It is described as a dry, native grassland on glacial outwash and lake plains with excessively well drained acid soil (MNFI 2003). It is dominated by big and little bluestem and Pennsylvania sedge, along with other common grassland species (Chapman 1984). Currently, only 17 occurrences exist, totaling 735 acres (Kost 2004). Only two of these occurrences are in the Grayling Subdistrict, in Crawford and Oscoda counties and total only about 120 acres (MNFI 2005b). The remnants of historic dry sand prairie are often found in depressions (Chapman 1984).

Dry sand prairies were originally maintained by high fire frequency, dry soils, and freezing temperatures, all of which prevented trees from becoming established (Kost 2004). Fire is also critical in retaining a diverse species composition, creating space for native species to grow and by opening up the seed bank. Most known prairies have succeeded to forest because of fire suppression (Kost 2004). In addition, many prairies were farmed during the 1800s but were abandoned because of the poor soil (Hauser 1953). These lands were also frequently planted to pine plantations as part of the national and state forest system (Chapman 1984). In fact, 82% of the remaining areas of good quality prairie soil are now managed by the Forest Service as pine plantations (USDA Forest Service 2005a). Many rare species are associated with the prairies, including prairie smoke *(Geum triflorum),* the ottoe skipper *(Hesperia ottoe),* and the regal fritillary *(Speyeria idalia)* (Chapman 1984). State threatened and endangered species include purple false-foxglove *(Agalinis skinneriana),* western silvery aster *(Aster sericeus),* prairie dunewort *(Botrychium campestre),* side-oats grama *(Bouteloua curtipendula),* Hill's thistle *(Cirsium hillii),* false boneset *(Kuhnia eupatoroides),* Leggett's pinweed *(Lechea pulchella),* furrowed flax *(Linum sulcatum),* prairie buttercup *(Ranunculus rhomboideus),* and bastard pennyroyal *(Trichostema dichotomum)* (USDA Forest Service 2005a). While not all of these species are currently found within in our project area, they may be components of restored dry sand prairies in the future.

Species of Dry Sand Prairies

Several of the most rare and endangered species associated with dry sand prairies in the Grayling Subdistrict are listed below. These species, which also occur in jack pine barrens, are described in detail in the preceding section.

- Blazing star borer *(Papaipema beeriana)*
- Dusted skipper *(Atrytonopsis hianna)*
- Grizzled skipper *(Pyrgus centaureae wyandot)*
- Hill's thistle *(Cirsium hillii)*
- Pale agoseris *(Agoseris glauca)*
- Red-legged spittlebug *(Prosapia ignipectus)*
- Rough fescue *(Festuca scabrella)*

Nonforested Wetlands

Wetlands in the Grayling Subdistrict are of varied types, and each is unique depending on its hydrology, geology, and vegetation. Some of the rarest wetland types are nonforested, including bogs, fens, intermittent wetlands, and prairie wetlands. Wetland systems are often named and characterized by the dominant plant community occupying the site. Each wetland type and several wetland species of special concern in the Grayling Subdistrict are described below.

Bogs (G5/S4)

A bog is described as a peatland characterized by sedge and floating sphagnum mats. Bogs occur in kettle depressions of pitted outwash terrain and in flat areas of glacial outwash and lakeplains. Bogs are isolated from groundwater sources as a result of peat accumulation and therefore receive water and nutrient inputs only from precipitation (MNFI 2006a). Since rainwater is typically ion-poor, bogs are ombrotrophic to weakly minerotrophic systems that are typically extremely acidic. Bogs are dominated by *Sphagnum* mosses and many acid-loving plants, such as bog rosemary *(Andromeda glaucophylla),* large cranberry *(Vaccinium macrocarpon),* round-leaved sundew *(Drosera rotundifolia)*, and many sedge species (MNFI 2003). State endangered and threatened species found in bogs include small round-leaved orchid *(Amerorchis rotundifolia)* and yellow fringed orchid *(Platanthera ciliaris)*. While bogs are considered relatively secure (ranked S4 and G5), they provide essential habitat for several rare and imperiled species.

Poor (G4G5/S3) and Northern (G4G5/S3) Fens

In general, fens are peatlands whose hydrology is influenced by groundwater. As a result most fens have higher nutrient availability, increased alkalinity, and greater species richness than bogs (MNFI 2006a). As poor fens are only moderately influenced by ground water, they are weakly minerotrophic and most similar to bogs in their soil and water chemistry. Poor fens are sedge-dominated systems that occur in kettle depressions or flat areas of glacial outwash and lakeplain. They contain both bog and fen species, such as few-seeded sedge *(Carex oligosperma),* few-flower sedge *(Carex pauciflora),* boreal bog sedge *(Carex paupercula),* tussock cottongrass *(Eriophorum spissum),* and tawny cottongrass *(Eriophorum virginicum)* (MNFI 2003).

Northern fens are located in areas of glacial drift underlain by calcareous bedrock only above the transition zone in Michigan. These sedge- and rush-dominated systems are influenced by

groundwater rich in calcium and magnesium carbonates (MNFI 2006a). Their soil and water chemistry is neutral to slightly alkaline. They are dominated by common Michigan lakeshore calciphile plants and northern white cedar (*Thuja occidentalis*), along with some typical bog plants (MNFI 2003).

Intermittent Wetlands (G3/S3)

Intermittent wetlands are herbaceous or shrubby wetlands with fluctuating water levels that fluctuate both seasonally and annually. They occur in depressions of glacial outwash and sandy glacial lake plains and in kettles of pitted outwash. The soils of intermittent wetlands range from loamy sand and peaty sand to peaty muck and are typically very strongly acid to strongly acid (MNFI 2006a). Some areas of this wetland types may have been created when fire destroyed bogs (MNFI 2003). Some state endangered and threatened species that exist in these wetlands include purple spike-rush *(Eleocharis atropurpurea),* Engelmann's spike-rush *(Eleocharis engelmannii),* three-awned spikerush *(Eleocharis tricostata),* hairy umbrella sedge *(Fuirena squarrosa),* dwarf bulrush *(Hemicarpha micrantha),* orangegrass *(Hypericum gentianoides),* whiteroot rush *(Juncus brachycarpus),* Vasey's rush *(Juncus vaseyi),* Leggett's pinweed *(Lechea pulchella),* northern appressed clubmoss *(Lycopodiella subappressa),* drumheads *(Polygala cruciata),* Carey's smartweed *(Polygonum careyi),* waterhead pondweed *(Potamogeton bicupulatus),* longbeak beaksedge (*Psilocarya scirpoides),* whorled mountain mint *(Pycnanthemum verticillatum),* meadow beauty *(Rhexia virginica),* lowland rotala *(Rotala ramosior),* Hall's bulrush *(Scirpus hallii),* nutrushes *(Scleria pauciflora and Scleria triglomerata),* eastern blue-eyed grass *(Sisyrinchium atlanticum),* and strict blue-eyed grass *(Sisyrinchium strictum)* (USDA Forest Service 2005a). In addition, intermittent wetlands can provide habitat for other target species such as the secretive locust *(Appalachia arcana)*, Doll's merolonche moth, ebony boghaunter *(Williamsonia fletcheri),* the Blanding's turtle *(Emys blandingii)* and the eastern massasauga *(Sistrurus catenatus catenatus)*.

Prairie Wetlands: Wet Mesic Prairies (G2G3/S2) and Mesic Sand Prairies (G2/S1)

Wet mesic prairies and mesic sand prairies are unique community types that are seasonally wet, with a high water table in the spring followed by drought conditions in late summer and fall (MNFI 2006a). As a result they often have a high diversity of plants, both common wetland and prairie species, that can withstand a range of moisture conditions. These prairies are found in landscapes of level sandy glacial outwash terrain with soils that are principally sandy loam, loamy sand, or sand soils and may be strongly acidic (MNFI 2003). Fire also plays a role in maintaining the open nature of these prairie systems (MNFI 2006a). Mesic sand prairies occur as small patches within fire-prone communities where the water table is near the soil surface. Often this community represents an ecotone between upland and wetland communities (MNFI 2006a).

Today this community is extremely limited: MNFI estimates that only a small portion (~2%) of the original upland prairie, which includes wet mesic and mesic sand prairies, remains in all of Lower Michigan. A high quality mesic sand prairie is found along a three-mile-long stretch parallel to Portage Creek at Camp Grayling Military Reservation. This wetland complex is home to a rare form of Houghton's goldenrod *(Solidago houghtonii)*, as well as Vasey's rush *(Juncus vaseyi)* and the secretive locust *(Appalachia arcana)* which are further discussed below (Higman et al. 1994).

Species of Nonforested Wetlands

Listed below are target species that can be found in one or more of the wetland types discussed above. Since many of these species have wide ranging habitats and/or little is known about their specific habitat requirements, we chose not to nest the species within specific wetland community types, but rather to treat them in a general sense.

Plants

Bayonet Rush (Juncus militaris) (G4/S1)

The bayonet rush is a member of the family Juncaceae and is a perennial plant (Dotflowers 2005). It is an obligate wetland species (MNFI 2005d), occurring in seven states, all of which are on the East coast except Michigan (Dotflowers 2005). In Michigan, it is found in intermittent wetlands and softwater lakes in lakeplain landscapes (MNFI 2005b). There is very little known about its biology in the state because of its rarity.

Canada Rice-grass (Oryzopsis canadensis) (G5/S2)

Oryzopsis canadensis is primarily a boreal species of grass, occurring across Canada and down into the northern United States in Michigan, Minnesota, Wisconsin, and New England, with disjuncts in the Appalachian Mountains (Gerdes 2006). In Michigan the species is listed as state threatened. It lives in dry to moist sandy soil with some gravel, as in wetlands and jack pine barrens (MNFI 2006d). It grows best in disturbed sites that expose sandy soil (Gerdes 2006). The only occurrences confirmed by the MNFI are in eastern Kalkaska county (MNFI 2005b).

Engelmann's Spike-Rush (Eleocharis engelmannii) (G4G5/S2S3)

E. engelmannii, also known as the Engelmann's spike-rush, is a member of the sedge family, Cyperaceae. It inhabits marshes and sandy wetlands, including intermittent wetlands and fruits from spring to fall, especially late August to September (MNFI 2005c). *E. engelmannii* has been found in 37 states and four Canadian provinces (eFloras 2005) and is considered a state species of concern in Michigan.

Houghton's Goldenrod (Solidago houghtonii) (G3/S3)

Solidago houghtonii is an endemic species found only in the Upper Great Lakes region, primarily along the northern shores of Lakes Michigan and Huron in Michigan and Ontario. A majority of the occurrences of *Solidago houghtonii* are restricted to narrow bands of open, calcareous, lakeshore habitat and appear to be strongly correlated with a dolomitic limestone formation known as the Niagaran Escarpment, which extends from the Bruce Peninsula and Manitoulin District in Canada to the southern shoreline of Michigan's Upper Peninsula to the Door Peninsula of Wisconsin (USFWS 1997). There are two main disjunct populations of the species: one in Genesee County, New York and one in Crawford County, Michigan, within the Grayling Subdistrict (USFWS 1997). Neither of these occurrences is associated with dolomitic limestone geology.

Solidago houghtonii was documented in the Grayling Subdistrict at the Camp Grayling Military Reservation in 1995. A high quality occurrence was recorded ranging from a small sandy

stretch of Highway M-72 to Howe's Lake and Portage Creek. Within the immediate vicinity of Howe's Lake and Portage Creek, numerous plants were documented in fen to wet-prairie habitat within a jack pine barrens/wet prairie complex. Another occurrence of a relatively small colony of plants was documented along the camp's entry or cantonment road.

Taxonomically, *Solidago houghtonii* is widely accepted as a distinct species, but there is disagreement among botanists and taxonomists about the species' origin and its genetic varieties (USFWS 1997). Morton (1979) suggested that *Solidago houghtonii* arose when Ohio goldenrod *(Solidago ohioensis)* and upland white goldenrod *(Solidago ptarmicoides)* produced a sterile hybrid that backcrossed with *Solidago ohioensis* and underwent chromosome doubling to produce the fertile hexaploid species now recognized as *Solidago houghtonii* (Penskar et al. 1996). However, others disagree. Pringle suggests that the species referred to as *Solidago houghtonii* may have arisen from at least four separate hybridization events. One of these distinct populations is the Michigan occurrence at Camp Grayling. This population represents the only octoploids of *Solidago* that may have resulted from the hybridization of *S. ptarmicoides* and a diploid race of *S. uliginosa* (USFWS 1997). If this is indeed the case, then the occurrence at Camp Grayling would represent a much rarer, more restricted taxon. This would certainly warrant increased protection efforts, specific protection under the Federal Endangered Species Act, and directed research of the Camp Grayling populations.

In a general sense, *Solidago houghtonii* is an herbaceous perennial with a thickened, branching base and a strong fibrous root system. The plant may be self-incompatible and require outcrossing and insect pollen vectors to successfully set seed (USFWS 1997).

Leggett's Pinweed (Lechea pulchella) (G5/S1S2)

Lechea pulchella is a perennial plant distributed from New England west to Indiana and south to Louisiana and Florida (Bowles 2004). In Michigan, the species is considered threatened. MNFI (2006c) reports that it occurs along the edges of seasonally inundated intermittent wetlands such as wet-mesic prairies and coastal plain marsh. Notoriously difficult to identify, pinweeds are small, grasslike herbs and are most easily found in July through September (Bowles 2004).

Northern Appressed Clubmoss (Lycopodiella subappressa) (G2/S2)

Lycopodiella subappressa is another relatively unknown plant, with an unknown distribution and unclear taxonomy. A member of the clubmoss family, Lycopodiaceae, it is found in moist, acidic peatlands, including wet mesic prairies and intermittent wetlands, and in the Grayling Subdistrict it occurs in borrow pits in Crawford county (Penskar and Higman 1996; MNFI 2005a). Best found from August to November, it grows to approximately 15 cm tall, with tiny, appressed leaves along its stem (Penskar and Higman 1996). It is listed as state species of special concern.

Vasey's Rush (Juncus vaseyi) (G5/S1S2)

Juncus vaseyi is a facultative wetland plant, distributed across the northern United States and Canada and considered threatened in the state of Michigan (Haines 2003). According to Haines, it has been linked to many different habitat types, but in Michigan it has been found in intermittent wetlands and wet mesic prairies and in swales along the border between Kalkaska and

Crawford counties (MNFI 2005b). A member of the Juncaceae family, it grows to between 20 and 70 cm tall and has narrow, mostly basal leaves with a white inflorescence (Haines 2003). It is best identified in July through September.

Animals

The most rare and endangered animal species associated with wetlands the Grayling Subdistrict are described below. The listed species, which may also occur in non-forested wetlands or uplands for a period of their life cycle are detailed either in the preceding section on jack pine barrens, as is the case with Doll's merolonche, or treated as special cases and detailed in the following section.

- Blanding's turtle *(Emys blandingii)*
- Doll's merolonche *(Merolonche dolli)*
- Eastern Massasauga *(Sistrurus catenatus catenatus)*
- Secretive Locust/Michigan Bog Grasshopper *(Appalachia arcana)*
- Wood turtle *(Glyptemys insculpta)*

Eastern Flat-Whorl (Planogyra asteriscus) (G3G4/S3)

The eastern flat-whorl is a snail species of special concern in Michigan (MI DNR 2004). It is terrestrial and is found in calcareous and shaded sites, mostly in boreal areas (Grimm 2005). There is little information on its life history and distribution in Michigan, but it is found in Kalkaska and Missaukee counties in the Grayling Subdistrict. According to the MNFI (2005a), it is found along creeks and rivers.

Ebony boghaunter (Williamsonia fletcheri) (G3G4/S1S2)

Williamsonia fletcheri is a dragonfly that has been documented from locations in Canada ranging from Manitoba to Quebec and from Maine to Wisconsin in the United States (NatureServe 2006b). Although the species is known from less than 100 occurrences, this number is most likely an underrepresentation of the actual number of populations as many parts of the species' potential range have yet to be inventoried (NatureServe 2006b). Within Michigan the species is known only from 17 occurrences across Chippewa, Gogebic, Grand Traverse, Mecosta, and Schoolcraft Counties (Michigan Odonata Survey 2005; O'Brien 2005). Only one of these occurrences, in Grand Traverse County, is found in the Grayling Subdistrict (MNFI 2005b).

The habitat of *Williamsonia fletcheri* is the lentic water of sphagnum-dominated bogs and fens. Its microhabitat is water-suspended or saturated sphagnum. Although little is known about the specific ecology and biology of *Williamsonia fletcheri,* it is suspected that the insect lays its eggs outside plant tissues of the moss and the larvae live within the saturated moss (O'Brien 2005; NatureServe 2006b). Adult specimens have been found in Michigan from late April—early May. Scattered individuals have been found sunning themselves in forest openings adjacent to bogs and fens. This may indicate that the species requires a specific combination of bog and upland habitat (O'Brien 2005).

There is no scientific consensus as to the minimum amount of habitat required to support populations of *Williamsonia fletcheri*. O'Brien (2005) estimates at least a half acre to acre of bog habitat is necessary to support a viable population. Also little is known as to why the species

occurs in certain bogs and not others. Research on *Williamsonia fletcheri* is often confounded by the early-season, narrow survey window and the relative lack of background knowledge about the species.

Rare Turtles of Concern

The following turtle species have been identified as individual targets since they require access to several vegetative community types for their habitat requirements and currently face specific threats that cannot be mitigated through habitat protection alone.

Blanding's turtle *(Emys blandingii) (G4/G3)*

The Blanding's turtle ranges across northeastern North America, from southwestern Quebec and southern Ontario south through the Great Lakes states into central Illinois and west to Iowa and Minnesota (Carr 1991). Although a statewide survey has not been conducted, the species has been reported from every county in the Lower Peninsula (Lee 1999a). There are 19 documented occurrences spread across the Grayling Subdistrict, with most occurrences clustered near river corridors (MNFI 2005b). The Blanding's turtle is a slow water turtle that inhabits backwater sloughs, ponds, marshes, swamps, bogs, wet prairies, and slow moving rivers. It will migrate from its aquatic habitat and can be found in a variety of terrestrial habitats (Harding 2006). The turtle may be searching for additional aquatic habitats, especially in the summer when shallow water habitats tend to dry up (Lee 1999a).

Blanding's turtles are active from early April until October. During this time they can be found basking on muskrat lodges, stumps, or logs (Lee 1999a). Blanding's turtles are omnivores whose diet consists of crayfish, aquatic insects, crustaceans, and aquatic plants. They will hibernate in mud or organic substrate at the bottom of water bodies (Carr 1991, Lee 1999a).

Mating usually occurs in the spring, with males often traveling substantial distances to find mates. Nesting occurs in open, sunny areas with moist but well drained sandy or loamy soil (Lee 1999a). Females reach sexual maturity between 14 and 20 years of age and will produce a maximum of one clutch per year, but not every female reproduces every year (Congdon et al. 1993). Clutch sizes range from 3 to 20 eggs with a mean of approximately 10 eggs. The clutch size has also been shown to increase significantly with body size. The annual survival rate of eggs in the nest is low, but adult survivorship is high and Blanding's turtles can reach 65−75 years in age (Congdon et al. 1993).

As with the closely related wood turtle, several life history traits of the Blanding's turtle are important for its conservation, including late sexual maturity, small clutch size, low reproductive success, high adult survival rates, and long adult life (Lee 1999a). Therefore, in order to maintain a stable population, it is crucial that a high percentage of adults and juveniles survive each year. Even the mortality of a few juveniles or adults can have significant impacts on the turtle population as their death represents the loss of many reproductive years (Lee 1999a; Congdon et al. 1993).

Wood turtle *(Glyptemys insculpta) (G4/S2S3)*

The wood turtle ranges across the eastern United States and Canada from Nova Scotia and New England south to Virginia and west through southern Ontario and Quebec into Wisconsin and northeastern Iowa (Carr 1991). In Michigan the wood turtle is found in the northern Lower

Peninsula and the Upper Peninsula (Lee 1999b). The wood turtle is a river turtle that does not wander far from its aquatic and floodplain habitat (Harding 2006). The turtle prefers clear, medium-sized, moving rivers with ample floodplain vegetation and sand bars, sand points, and cutbanks for nesting (Lee 1999b). Within the Grayling Subdistrict, the wood turtle has been observed on the middle part of the Muskegon River (Harding 2006).

The wood turtle is a long-lived species that does not reach sexual maturity until it is 12 to 20 years old. Once sexually mature, the turtles will mate in shallow water during the turtle's active season (April–October). Females produce one clutch per year, which ranges from 5 to 18 eggs, with an average clutch size of 10.5 eggs. The hatchlings emerge in late August or September (Lee 1999b).

Wood turtles will enter hibernation around mid-October. They overwinter in moving streams under overhanging roots or logs, in pools along stream bottoms under the ice, or in beaver lodges or muskrat burrows (Lee 1999b). In the active season, wood turtles spend most of their time basking in the sun and feeding. Wood turtles are opportunistic omnivores whose diet is composed of food items such as algae, leaves, fish, insects, and snails (Carr 1991; Lee 1999b).

Several of the wood turtle's life history traits are important for its conservation, including its slow growth, late sexual maturity, low reproductive success, and long adult life (Lee 1999b). Therefore, in order to maintain a stable population, it is crucial that there is a "high annual survivorship of adults and juveniles" (Harding 2006, Lee 1999b). Wood turtles also have a reputation as intelligent, engaging pets. This temperament, in addition to their ease of collection, makes wood turtles an easy target for the pet trade (Harding 2006).

Eastern Massasauga *(Sistrurus catenatus catenatus) (G3G4/S3S4)*

In our conservation plan, the eastern massasauga is treated as a separate target as it utilizes several vegetative community types during the different stages of its life cycle. Also there are threats to the massasauga that will not be mitigated solely through habitat protection. As a result it is insufficient to assume that conservation of its habitat community types will necessarily ensure protection of the massasauga. Moreover, it is a candidate for federal endangered species listing and thus is subject to many different regulations and management restrictions than other species.

Sistrurus catenatus catenatus is Michigan's only rattlesnake, a medium-sized snake with distinct dark brown patches along its back on a gray or brown background. Once common, it now survives in isolated populations from Minnesota south to Iowa and east to Ontario and New York (Lee and Legge 2000). The state of Michigan can be considered a stronghold for the species, with extant populations (approximately 150) documented across the Lower Peninsula and more occurrences (historical and current) than any other state (Lee and Legge 2005). A systematic statewide field survey has not been conducted for this species, so its actual distribution and abundance is unknown. Numerous occurrences of *S. catenatus* have been counted across the Grayling Subdistrict, with a concentration in Crawford and Kalkaska counties (MNFI 2005b). Lee estimates that there may be more than 50 occurrences in the Grayling Subdistrict (2005).

The habitat for *S. catenatus* in the Grayling Subdistrict includes open upland areas with adjacent shade and wetlands that have water at or near the surface for hibernation (Lee 2005).

In addition, streams and conifer systems have been shown to be predictors of *S. catenatus* populations (Kingsbury 2005). In the inactive period the massasauga utilizes hibernacula in or near wetlands—the proximity to water helps keep their bodies from freezing during hibernation (Kingsbury 2005). However, in the Grayling Subdistrict, the snakes have also been found hibernating in upland areas such as pine barrens (Lee 2005). After hibernation, they shift from wetlands to uplands for the spring and summer. During this active period, the snakes require upland habitat with patchy vegetation that provides both open areas for thermoregulation and shrubs for cover. This habitat is particularly important for gravid females who spend more time in open areas sunning themselves (Lee and Legge 2000).

The home ranges of *S. catenatus* individuals differ between northern Michigan populations and populations found elsewhere in the species' range. Studies have shown that in the Grayling Subdistrict, individuals may have increased movement within their range as compared to snakes in other areas (Lee 2005). In general, young snakes and gravid females move the least distance, while males have the largest home ranges (Lee and Legge 2000).

S. catenatus is a candidate for federal listing as an endangered species. In an attempt to protect the species before it requires listing under the Endangered Species Act, the U.S. Fish and Wildlife Service has drafted a candidate conservation agreement in Michigan and several other states.

Secretive Locust/Michigan Bog Grasshopper *(Appalachia arcana) (G2G3/S2S3)*

The secretive locust, or Michigan bog grasshopper, is aptly named. Very little is known about it other than that it appears to be endemic to northern Michigan and lives on the trunks of trees and shrubs. In the Grayling Subdistrict it requires habitat that is shrubby but open enough for full sun, such as bogs with leatherleaf and Labrador tea, sphagnum, stands of jack pine and tamarack, open groves of aspens and pines with bracken fern and sweetfern, early shrub thicket stages of second-growth hardwood forests, shrubby undergrowth in jack pine barrens, northern wet prairies and intermittent wetlands (Rabe 1996). There are 39 documented occurrences in the Grayling Subdistrict, concentrated in Crawford, Oscoda, Roscommon, Clare, and Otsego counties (MNFI 2005b).

Part III: Methods, Results, and Discussion

Chapter 6: The Five-S Process and Conservation Action Planning

Overview

This chapter describes The Nature Conservancy's (TNC's) conservation planning process and how we implemented it. We combined the background information and conceptual approach discussed in chapters 2 and 3 with knowledge gained through our literature search, meetings, and interviews to determine and rank viability, threats, and strategies for our target communities and species. Chapter 7 describes our interview and GIS analysis methodology, chapter 8 identifies the threats to our targets, and chapter 9 discusses the proposed strategies to abate those threats.

Conservation Action Planning

As mentioned in chapter 1, The Nature Conservancy follows the *Conservation by Design* framework for ecoregional planning and the conservation of biodiversity. For specific sites, the *Five-S Framework for Site Conservation* is the method used by TNC to lay out strategies and measures of success for conserving the chosen conservation targets. The *Five-S Framework* is put into practice through Conservation Action Planning (CAP), with the bulk of the planning documented in a Microsoft® Excel workbook. The CAP process covers three sections of the conservation approach (outlined in chapter 1): developing strategies, taking action, and measuring success (TNC 2005).

CAP is a 10-step process developed by TNC to guide the planning process towards meaningful strategies (TNC 2005) (figure 10). The 10 strategies are listed below.

1. Identify people involved in the project—the team that will create the plan and any leaders and advisors.
2. Define project scope and focal conservation targets—the project area and the systems or species that will be the focus of the planning process. This is also known as the *systems* part of the Five-S process.
3. Assess viability of focal conservation targets—the current status of each target in terms of landscape context, population, and other factors and goals for the future.
4. Identify critical threats—determining and ranking threats to each target. This is also known as the *stresses* part of the Five-S process.
5. Conduct situation analysis—this connects stakeholders to the status of and threats to the targets. This is also known as the *sources* part of the Five-S process.
6. Develop strategies: objectives and actions—drafting and prioritizing strategic actions that will change the status of the targets toward the goals set in the viability analysis. This is also known as the *strategies* part of the Five-S process.
7. Establish measures—this is needed to monitor whether the strategies are having the desired effects or if other targets, threats, or strategies need to be considered. This is also known as the *success* part of the Five-S process.
8. Develop work plans—specifics about who will be implementing what strategies and the resources needed.
9. Implement—putting the strategies set forth in the plan into action.
10. Analyze, learn, adapt, and share—continually evaluating the success of the project and determining the next steps to take. In addition, it means sharing what you have learned in the process with others.

Figure 10. Diagram of the Conservation Action Planning cycle and its steps (TNC 2005).

As part of our project, we completed steps 2 through 6 using the Excel workbook; our methods are described in detail below. The remainder of the steps will be performed by TNC staff as they refine the plan and put it into practice.

The Planning Workbook

The CAP workbook consists of multiple spreadsheets with extensive automation to guide the user through the CAP process of entering and documenting planning information. The CAP workbook ensures all TNC conservation plans are usable and consistent across projects. Throughout the workbook, there are various instructions and prompts to help the user enter and prioritize appropriate information. In addition, there are places to add commentary and documentation that can be printed out in a word processing format. The workbook is continually updated with improved programming and instructions to help the user. For this project, we used version 4b, released in September 2005 (figure 11).

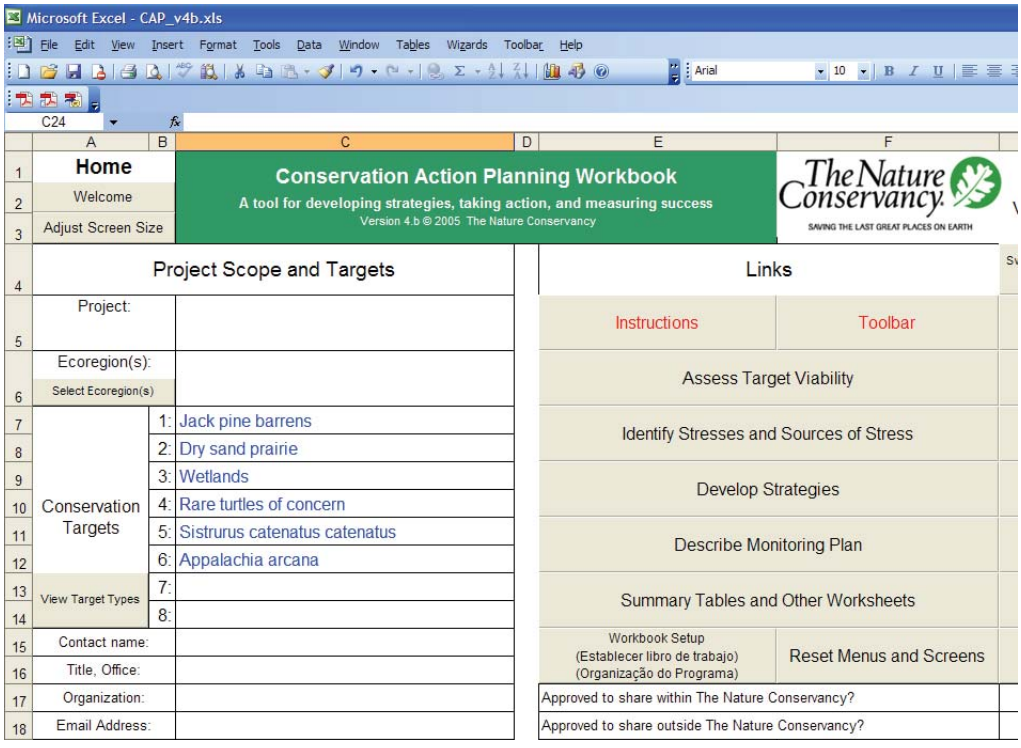

Figure 11. Screenshot of the first page of the Conservation Action Planning workbook.

Targets

The first step in using the CAP workbook is to determine the focal targets of the conservation plan. Targets can be either single species, communities, or whole ecosystems that encompass many species, depending on the scope of the plan. A helpful tool for determining if a species, community, or ecosystem is a suitable target is below (figure 12).

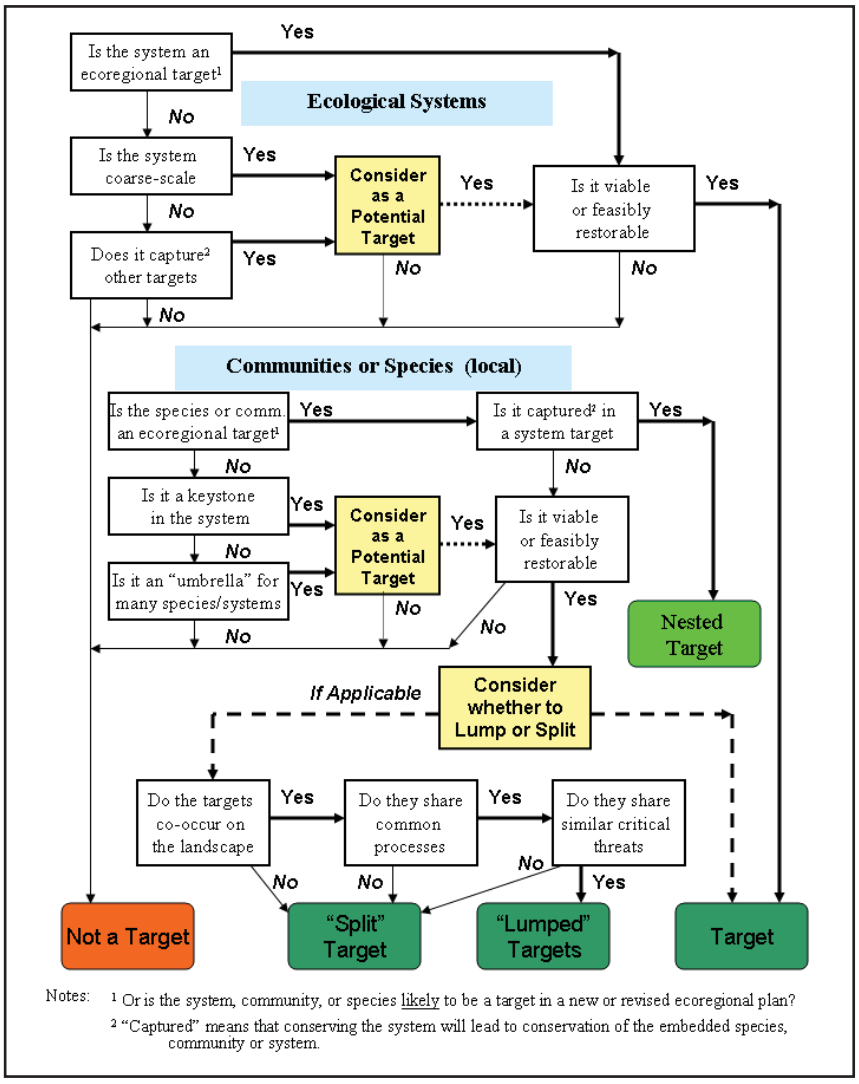

Figure 12. Flow chart illustrating the selection process for conservation targets (courtesy of The Nature Conservancy).

Targets Included in this Project

We chose a combination of community types, groups of species, and single species as our targets, which are described in detail in chapter 5. This determination was based in part on the NatureServe global and state rankings, specifically those ranked as S3, S2, or S1 or G1 (see appendix A). We also considered species and communities when they were highlighted in our research meetings, literature searches, and personal interviews with agency and academic experts (see chapter 7 for a more detailed discussion of our data gathering process). We then worked with our client to determine which communities and species were the most appropriate to focus on in this initial conservation plan for the subdistrict. The targets are:

- Jack pine barrens

- Dry sand prairies
- Nonforested wetlands
- Rare turtles of concern (Blanding's turtle *(Emys blandingii)*, wood turtle *(Glyptemys insculpta)*)
- Eastern massasauga *(Sistrurus catenatus catenatus)*
- Secretive locust *(Appalachia arcana)*

Jack pine barrens are our primary focal target because they historically encompassed a large area of the Grayling Subdistrict and are currently severely threatened. In addition, this community occurs within ecosystems that support many rare and endangered species. Other communities featured in our plan are dry sand prairies and wetlands. While both of these host many rare and endangered species of plants and animals, they constitute a much smaller area than the jack pine barrens. We grouped two rare turtles, Blanding's turtle and the wood turtle into one target because they face similar threats that are unique to turtle species and use a combination of wetlands and open community types during their life cycles. Two single species, the eastern massasauga and the secretive locust, are listed as separate targets because they are known to inhabit more than one community during their life cycles and are also subject to unique threats. Many single species are considered "nested" targets because they are contained within the community-type targets. By focusing conservation efforts on community types, it is understood that these nested species will also benefit.

Excluded Targets

There are many species that we chose not to include in this project because they are not endemic to the subdistrict or were beyond the scope of our project (some of these species are listed in chapter 10). For instance, there are many rare species associated with dry sand prairies in other parts of the state, but since they have not been documented in our project area (MNFI 2005b), we did not include them in the project. It is possible, however, that these species could be found in the Grayling Subdistrict if further surveys were conducted or if restoration of larger areas of prairie allowed them to populate the area. In addition, we did not consider aquatic species or systems. We feel that a separate conservation plan should be undertaken to cover the important watersheds and lakes in the area, such as the AuSable and Manistee Rivers and Higgins and Houghton Lakes. The rare fish, snails, and plants that are associated with these aquatic ecosystems should be covered in depth, but we did not have the resources to include them in our plan. Finally, we excluded several species that were ranked S1 through S3 or G1 because they are not associated with our main community types. Most of these species occur in dry deciduous forests, and many have a wide-ranging distribution so that a special focus on them in the Grayling Subdistrict may not be the best way to ensure their survival.

Key Attributes and Viability

After determining the focal conservation targets for the project, we assessed the viability of the targets—their current condition and need for conservation. As a first step in our viability assessment we identified the key attributes of each target, which were chosen from a list provided in the spreadsheet or entered manually. The CAP workbook categorizes key attributes into landscape context, condition, and size. Landscape context attributes include information about the location, geology, hydrology, fire regime, and more. Condition attributes include information about the quality of species or communities in terms of species composition, and size attributes include information about occurrences, whether they are populations or com-

munities. To address the multiple aspects of each target, we tried to include at least one key attribute from each category.

Once we chose the key attributes, we determined indicators that were used to assess the status of each attribute. Indicators are intended to be quantitative measures so that the status of an attribute can be clearly marked and future goals are easy to calculate. For instance, one of our key attributes for jack pine barrens is fire regime and the indicator we chose was fire size. Therefore, the size of the fires in the subdistrict, measured in acres, can be used to assign the status of the key attribute a rating of poor, fair, good, or very good. We also provided justification and documentation to back up each rating in the workbook. To complete this task, we used a combination of literature and interviews with scientific and agency experts on the community types and species in the Grayling Subdistrict. See figure 13 for TNC's diagram with tips for determining appropriate attributes and indicators.

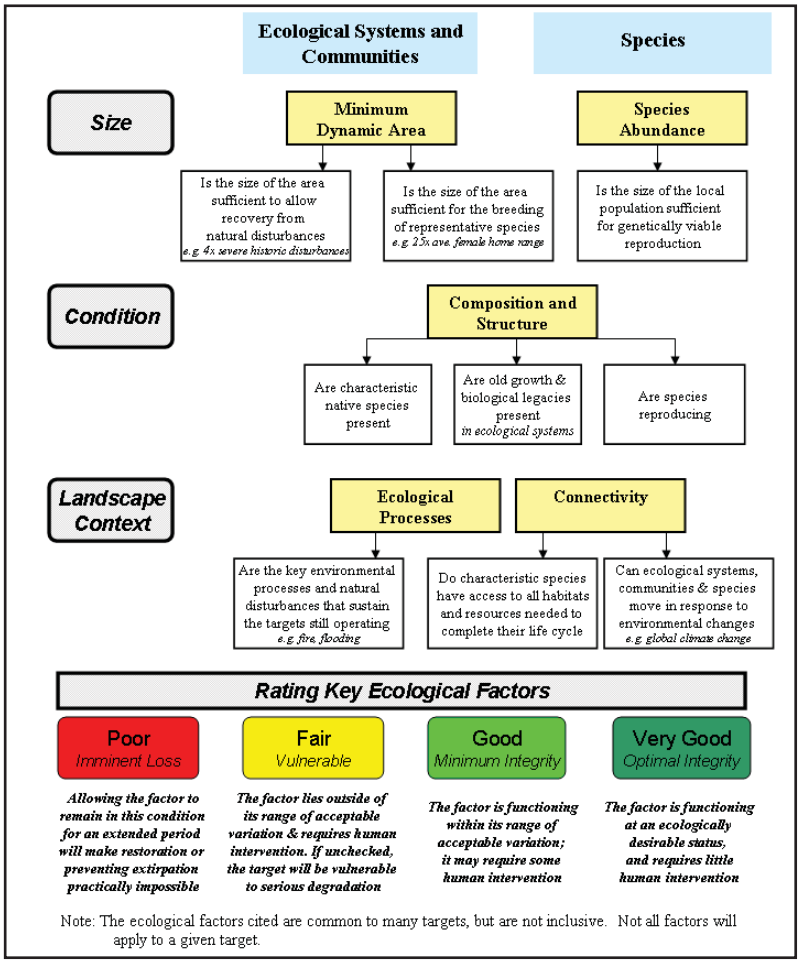

Figure 13. Diagram of the viability assessment tool showing representative key ecological attributes (courtesy of The Nature Conservancy).

In the next step, we set the desired ratings for the indicators, which are the future goals of implementing the completed conservation plan. The ranking system is the same for desired ratings as for current ratings: poor, fair, good, and very good. Using the current status indicators and information from literature and our interviews, we set the desired ratings as the same or higher than the current status ratings. In each case, we considered the ideal rating and then adjusted it to a more feasible level after taking into account management, societal factors, and other issues that would affect the difficulty of improving the status of the indicator.

See appendix B for a complete list of the key attributes and indicators and the documentation of the viability analysis.

Stresses and Their Sources (Threats)

Once we completed the viability analysis, the next step was to identify the stresses to each target and the sources of those stresses. To do this, we first looked at the target attributes that were ranked most poorly, shown through an automated function on the stress page of the worksheet. Next, we ranked the severity and scope of the stress to those attributes, which led to an overall stress rank for each attribute (figure 14). Finally, we listed the human activities that cause the stresses to attributes and ranked their contributions and irreversibility for each attribute that they affected. See chapter 8 for a detailed discussion of the threats and appendix B for a complete list of stresses, their sources of stress, and severity rankings.

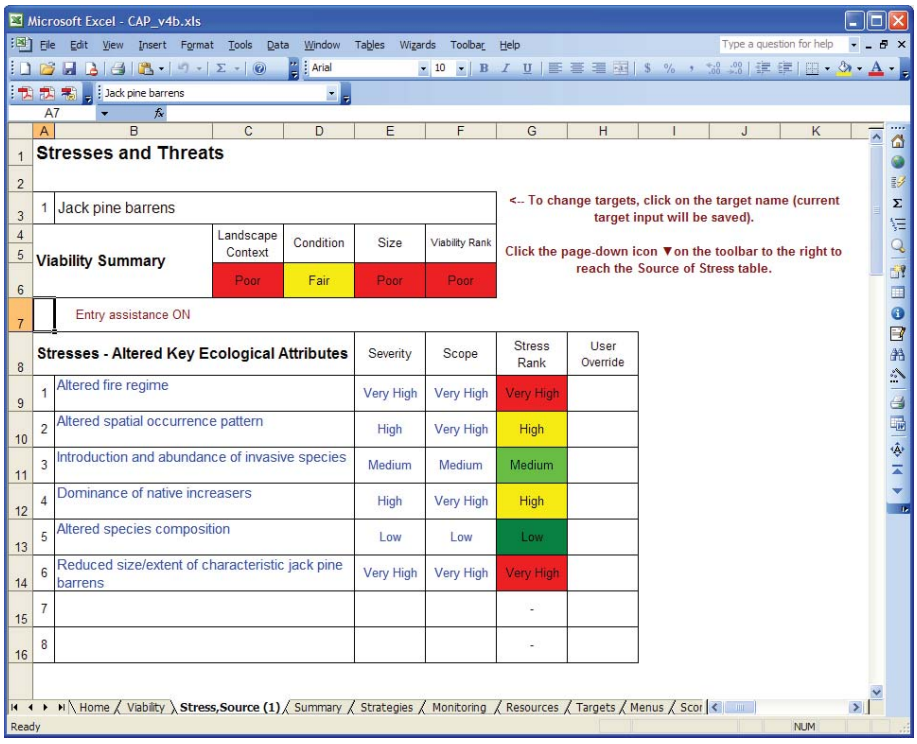

Figure 14. An example of the ranked stresses for the jack pine barrens community type.

Stresses to Key Attributes

The workbook's automated process changes the colors of the ranks in the summary so that the user can see which stresses are most critical: low stresses are marked with dark green, medium with light green, high with yellow, and very high with red. For these rankings, the workbook uses a formula to determine the overall stress level from the rankings chosen by the user for scope and severity of an attribute; however, this overall level and subsequent rankings can be overridden by the user if the formula-determined output does not seem reasonable. In this part of the sheet, the possible rankings are low, medium, high, or very high.

Sources of Stress (Threats)

In the CAP process, threats to conservation targets are considered as any factor, human-related or otherwise, that causes stress to a target's condition, size, or landscape context in the form of degradation or other impairment (TNC 2003). In the CAP workbook, the stressed attributes and their stress ranks are filled into a table where threats can be entered and subsequently ranked

for each individual stress in terms of their contribution to the stress of the attribute and the irreversibility of the actual threat (figure 15). Each threat does not necessarily affect each stressed indicator, and the threat ranks determined through a formula can be overridden as above.

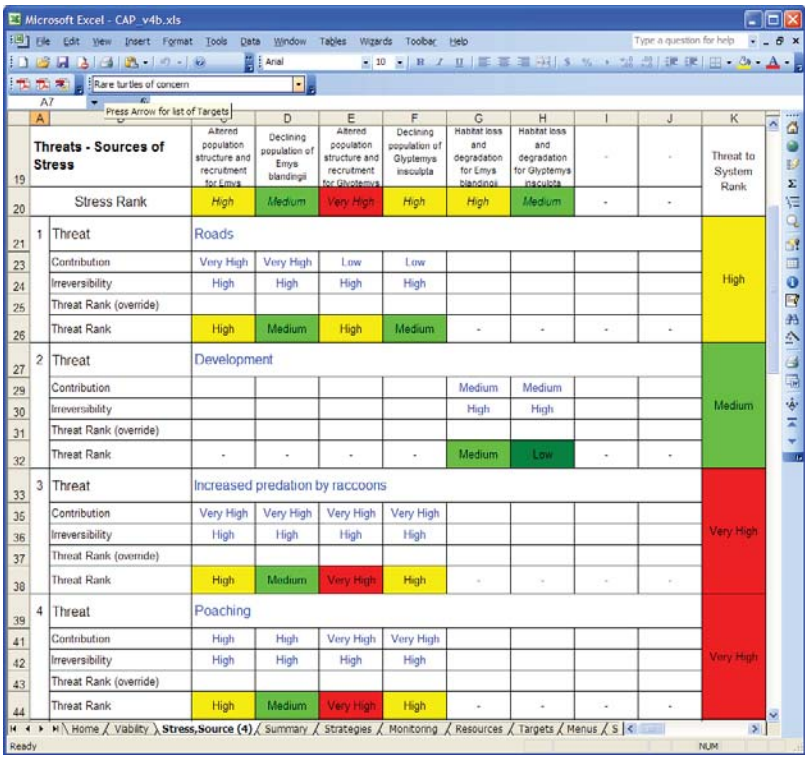

Figure 15. Example of the ranked threats for the rare turtles of concern.

Once the threats have been listed and ranked for each applicable attribute, the overall rank for each threat is assigned as a measure of the threat it poses to the entire target. The threats are then added to a summary table automatically (figure 16 below). The threats with the highest rankings across the most targets are considered the most critical.

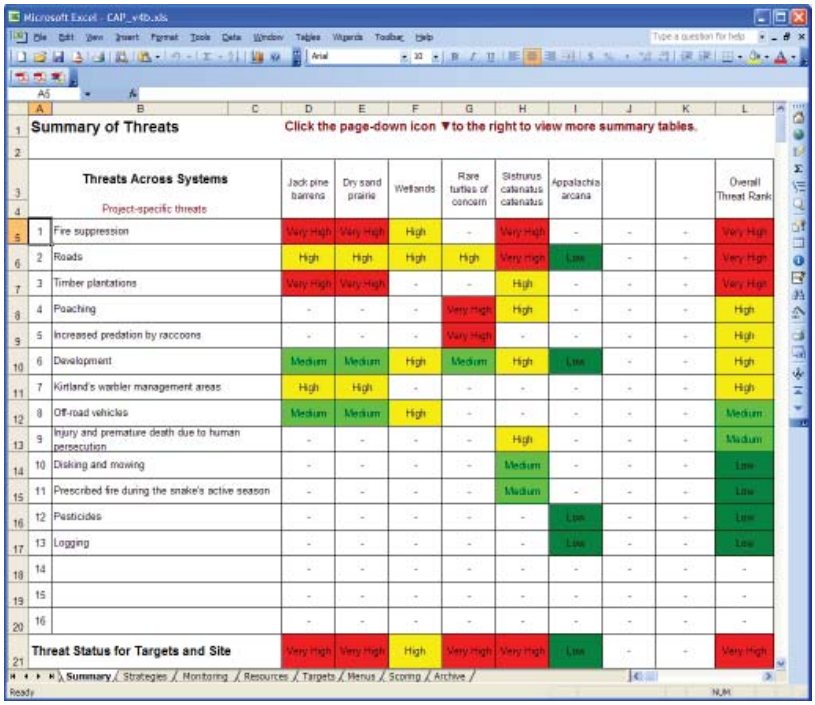

Figure 16. Summary of the ranked threats of the conservation targets for the Grayling Subdistrict.

Strategies for Conservation

The final segment of the CAP process that we completed was the strategies section of the workbook. This process entailed reviewing the threats and designing potential strategies for TNC and other stakeholders in the area. First we identified the overall objectives in the strategies section of the workbook. These objectives address specific threats and are prioritized according to the threat level and structured consistently with the potential timeline for completing the plan, including dates and quantitative measures wherever possible.

Within each objective, we determined the most important strategic actions needed to complete the objective. Strategies are more discrete, detailed actions that identify possible partners and specific tasks. They can be prioritized within each objective, and the same strategy can be used to address multiple objectives. In the workbook, strategies can be viewed either grouped under the objectives they apply to or as strategies with the applicable objectives attached (figure 17). See chapter 9 for a detailed discussion of the strategies and appendix B for a complete list of objectives and strategies.

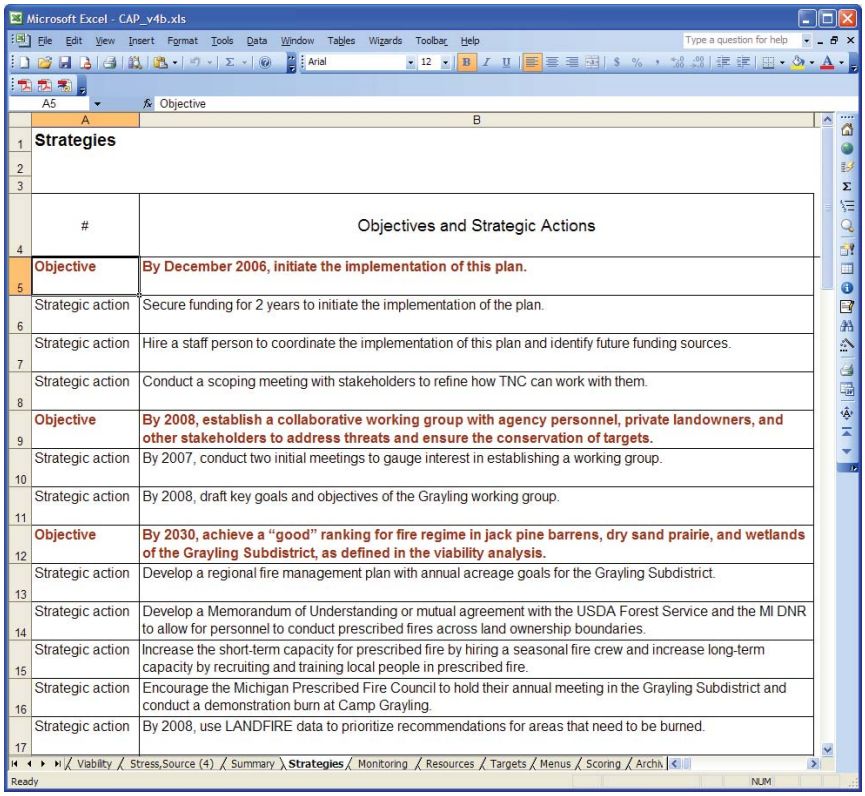

Figure 17. Example of the objectives and strategic actions to abate the threats to the conservation targets.

Part III: Methods, Results, and Discussion

Chapter 7: Data Gathering and Analysis

In developing a conservation plan for the rare community types and organisms of the Grayling Subdistrict, we collected, analyzed, and integrated ecological, managerial, and sociological information on the region. This information was gathered through literature reviews, interviews with scientists and land managers, and Geographic Information Systems (GIS) analysis.

Literature Review and Interviews

We began with a literature review of books and articles about the basic geology, ecology, and natural history of the Grayling Subdistrict. Then we focused on particular community types and species of concern. We compiled and narrowed a list of potential target community types and species by examining lists of endangered, threatened, and sensitive species and communities and by consulting with scientists. We used the Michigan Natural Features Inventory's (MNFI) Biotics database as well as their lists of special plants, animals, and communities to find out which species and communities ranked S3, S2, or S1 or G1 occurred in the Grayling Subdistrict (see appendix A for an explanation of the ranking system). We also searched the USDA Forest Service's Regional Forester's Sensitive Species list and the U.S. Fish and Wildlife Service's list of threatened and endangered species for additional species to consider as targets or nested targets. We then searched libraries, journals, and online sources for any relevant information on our potential target communities and species. MNFI's species and community abstracts and the NatureServe Explorer website served as particularly important sources of ecological information.

We conducted interviews with experts to gather further ecological and managerial information about species and communities and to prioritize and narrow down our list of targets. We initially held small group meetings with USDA Forest Service and MI DNR staff and later contacted individuals by telephone (see appendix C for a list of contacts). We particularly relied on these experts to assess the viability of the conservation targets, since the size and nature of our project prevented us from conducting field research ourselves.

GIS Analysis

We also consulted and analyzed GIS data to assist in developing the conservation plan. A database of species and community occurrences provided us with spatial information on species and communities that have been documented by MNFI. We also studied data on Landtype Associations (LTAs), presettlement and current land cover, and land ownership. Finally, we worked with a data set created by TNC that documents the extent and type of change in land cover between 1800 and 2000. Using these data sets, we created new data layers depicting where barrens and nonforested wetlands may currently exist or have potential for restoration (figures 18 and 19).

To aid in our selection of targets and assessment of viability, we used the MNFI biotics database, 1800 presettlement land cover, and 2000 land cover GIS layers. The biotics layer was clipped to match the boundaries of the Grayling Subdistrict by using the ecoregions layer. We then used the biotics attribute table to find out which species and community types had been documented by MNFI within the Grayling Subdistrict. This list of occurrences informed our target selection but was not the only source, since the MNFI biotics database is not comprehensive. We consulted other lists and spoke with scientists as well.

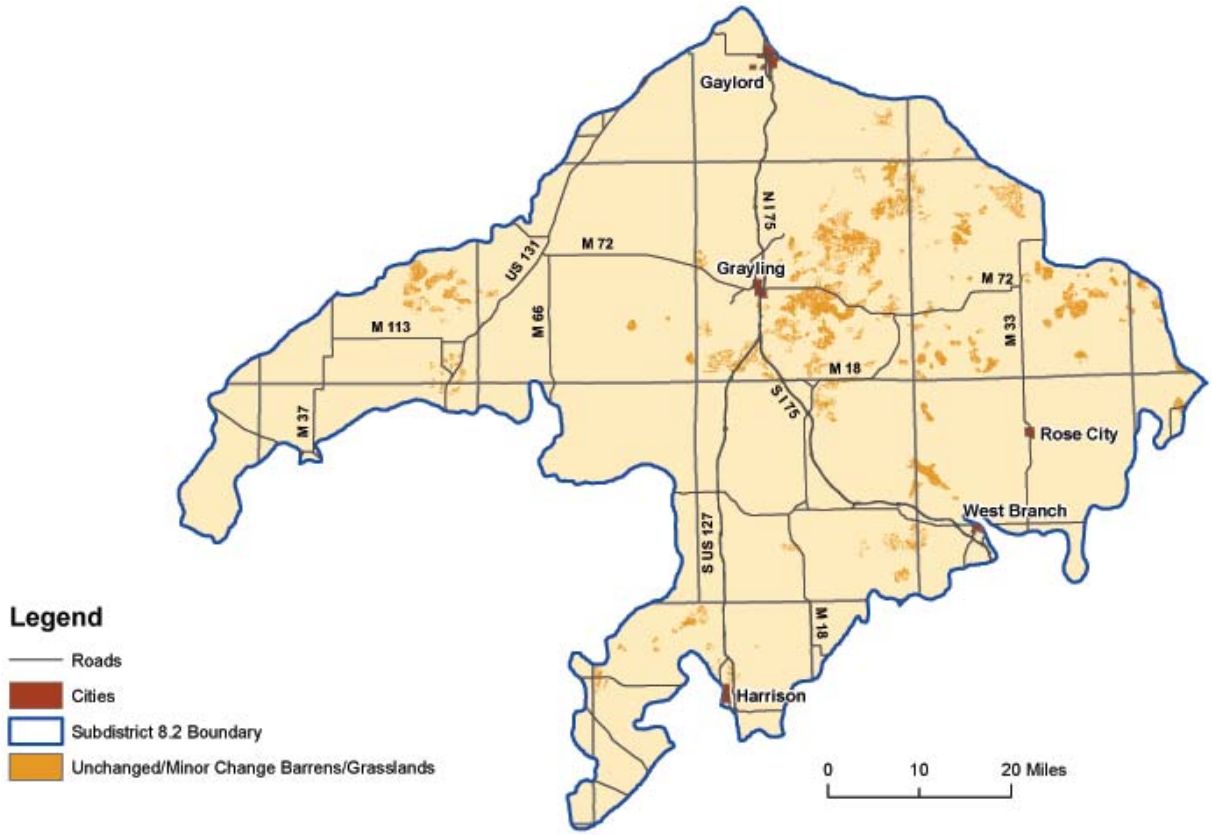

Figure 18. Map of remnants of jack pine barrens and grassland remnants in the Grayling Subdistrict of northern Lower Michigan (Michigan Geographic Data Library 2005; MNFI 2005a).

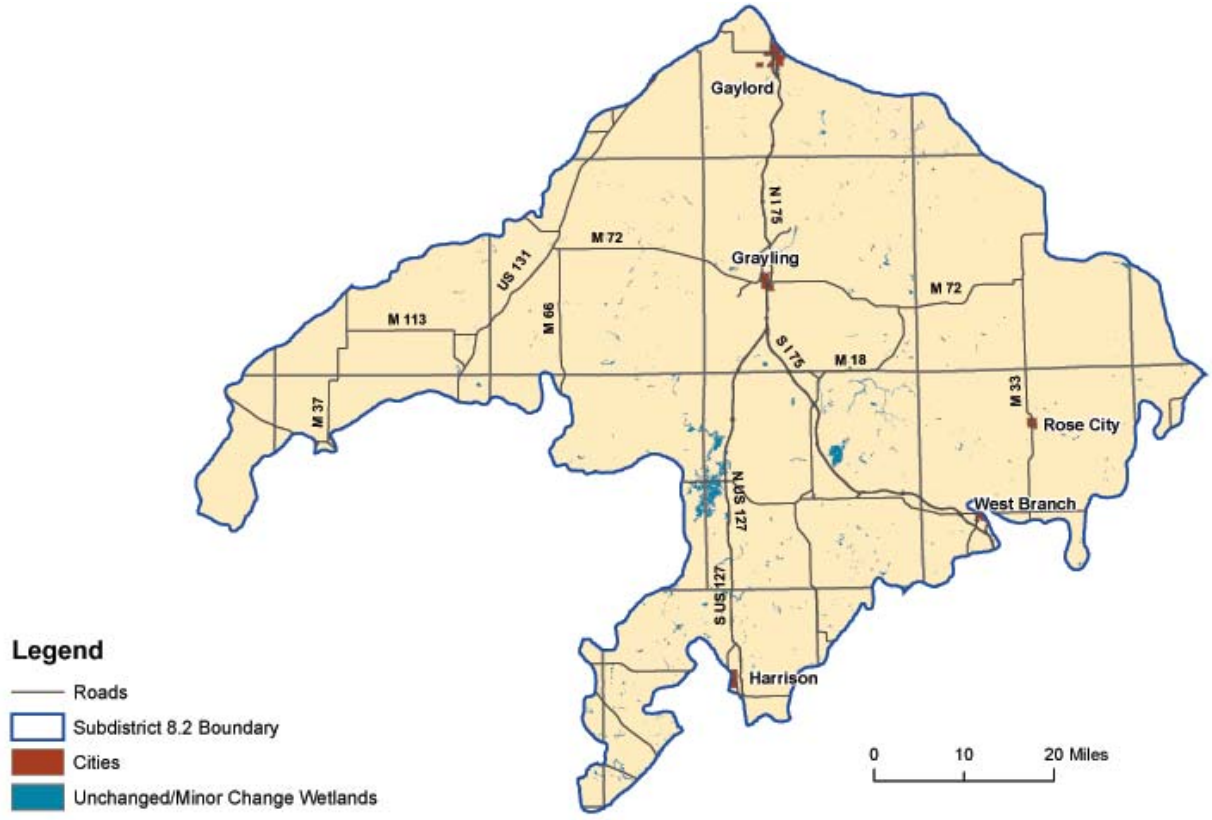

Figure 19. Map of remnants of nonforested wetland in the Grayling Subdistrict of northern Lower Michigan (Michigan Geographic Data Library 2005; MNFI 2005a).

In addition, we used the 1800 presettlement land cover layer to find out the historical distribution of target vegetative communities such as pine barrens, prairies, and nonforested wetlands. We compared this data to the 2000 land cover layer. Since the land cover classifications differ between these layers, and the 1800 layer was developed using very different techniques (historical land surveys for the 1800 layer and satellite images for the 2000 layer), we had to use educated guesses about which land cover types were comparable between the two layers. In the 1800 layer, we looked at communities designated grassland, pine barrens, muskeg/bog, and shrub swamp/emergent marsh. In the 2000 land cover layer we considered herbaceous openland, upland shrub/low-density trees, emergent wetland, floating aquatic, lowland shrub, and mixed non-forest wetland.

A more complex portion of our GIS analysis consisted of identifying potential areas for prairie, jack pine barrens, and nonforested wetlands restoration. To do this we analyzed a "change grid" raster dataset that depicts how much an area deviates from historical land cover. It also contains information on the type of change between 1800 and 2000 (for example, from oak/pine barrens to aspen). The MNFI developed this dataset of the Lower Peninsula of Michigan by overlaying an 1800 vegetation layer on the 2000 IFMAP land cover grid. Change levels include: unchanged (1), minor change (2), natural (3) or anthropogenic (4) major change, unrestorable (5), changed to water (7), and water unchanged (8). We chose a set of appropriate change classes and land cover combinations to ascertain potential locations of current or restorable prairie, pine barrens, and wetlands. Since this is a coarse-level analysis, we chose to include any kind of barrens or grassland in 1800 and elected to use all of the change combinations for land cover types of interest that were considered a "1," unchanged, or "2," minor change (see appendix D for the specific combinations). The result was a new set of layers depicting areas that had historically been pine barrens, prairies, or wetlands and have relatively similar vegetation today (figures 18 and 19).

The assumption underlying this analysis was that landscape ecosystems that historically supported these community types that have experienced little change in vegetation would be more restorable than areas that experienced drastic changes in vegetation and land use over the last 200 years. TNC should "groundtruth" and verify the potential prairies, barrens, and wetlands identified through this type of analysis before implementing any actual restoration work.

Potential Applications

The data layers depicting potential barrens, prairies, and wetlands can be overlaid with a land ownership data layer to determine whether potentially restorable locations are in public or private ownership. Land managers should be interviewed further to assess the quality of any existing barrens, prairies, and wetlands and the feasibility of restoration on other potential sites. High-quality sites, areas that cross ownership boundaries, or sites falling mainly on private land should be highlighted for special consideration.

In addition, TNC could conduct an analysis to determine the relationship between the relatively unchanged barrens and prairies (as identified in this analysis) to landtype associations. If such a relationship exists, this information could assist TNC and other land managers in identifying appropriate landtype associations for barren and prairie restoration sites.

Part III: Methods, Results, and Discussion

Chapter 8: Threats

As described in chapter 6, the Conservation Action Planning workbook that we used as a planning tool required us to identify stresses and the sources of these stresses (threats) to the targets. This chapter describes several of the major stresses and sources of stress affecting the communities and species that we identified as targets. For a complete list of the stresses and sources of these stresses we documented in the planning workbook, see appendix B. As described in chapter 6, the workbook summarizes threats across all systems and assigns each a categorical overall threat rank—very high, high, medium, or low (see the Threats Summary Table in appendix B). These threats provided the basis for drafting conservation strategies to guide The Nature Conservancy's work in the Grayling Subdistrict.

Stresses

Invasive Species and Native Increasers

From conversations with regional land mangers and scientists who work in the Grayling Subdistrict, we recognized that invasive species are a stress to several of the focal targets (Schmidt 2005; Kost 2005; Cleveland 2005). Specifically, the presence of invasives such as smooth brome *(Bromus inermis)*, spotted knapweed *(Centaurea maculosa),* autumn olive *(Elaeagnus umbellata)*, orange hawkweed *(Hieracium aurantiacum)*, common St. John wort *(Hypericum perforatum)*, Canada bluegrass *(Poa compressa)*, multiflora rose *(Rosa multiflora)*, and common sheep sorrel *(Rumex acetosella)* threaten the quality of jack pine barrens and dry sand prairies. Currently, most invasives are primarily confined to roadsides and edges of trails, yet they have the potential to spread and out-compete native plant species. Also, native species such as sweetfern *(Comptonia peregrina)* bracken fern *(Pteridium aquilinum),* and Pennsylvania sedge *(Carex pensylvanica)* have a tendency to form monocultures, out-competing other barren and prairie species.

In wetland systems of the Grayling Subdistrict invasive species can pose a substantial threat to the quality of the wetland. Common invasives include redtop *(Agrostis gigantea)*, spotted knapweed, leafy spurge *(Euphorbia esula)*, orange hawkweed, common St. John wort, purple loosestrife *(Lythrum salicaria)*, Eurasian water milfoil *(Myriophyllum spp.)*, Canada bluegrass, giant reed *(Phragmites australis)*, lawn prunella *(Prunella vulgaris)*, goat's beard *(Tragopogon dubius)*, and reed-canary grass (*Phalaris arundinacea*) (MNFI 2006a). These species can quickly invade wetland systems, threatening native biodiversity.

Lack of Scientific Information

The lack of scientific information is another major stress to the effective conservation of the target community types and species. Although it is infeasible to have complete demographic and population distribution information for each natural communities and species in the Grayling Subdistrict, the lack of information on specific species makes it difficult to design strategies for the species. For example, the ebony boghaunter *(Williamsonia fletcheri)* is known within Michigan from only 17 occurrences (Michigan Odonata Database, O'Brien 2005). The boghaunter may actually be more widespread, yet no one is looking for it (O'Brien 2005). There is also limited information on the life history, distribution, and abundance of the secretive locust *(Appalachia arcana)* (Rabe et al. 1996). In addition, there is practically no information on the doll's merolonche *(Merolonche dolli),* the eastern flat-whorl *(Planogyra asteriscus)*, and the deepwater pondsnail *(Stagnicola contracta).* The apparent lack of information on insect species was made evident by the MNFI surveys conducted at Camp Grayling. The

two-year study documented five new occurrences of the secretive locust, 14 new species state records, and two species that may have been new to science (Higman et al. 1994).

Additional Stresses

We identified a multitude of other stresses such as an altered spatial pattern of occurrence, altered species composition, reduced size and extent of target communities, soil degradation, altered hydrologic regime, decline of species of conservation concern, limited recruitment, habitat loss and degradation, and population decline. Since stresses and the sources of the stresses are closely tied, these additional stresses are discussed in conjunction with the appropriate threat in the following section.

Sources of Stress (Threats)

Altered Fire Regimes

Altered fire regimes, particularly widespread fire suppression, are a very high-level threat to the community-type targets of jack pine barrens, dry sand prairies, and non-forested wetlands. One of the primary driving factors in the creation and maintenance of jack pine barrens, dry sand prairies, and non-forested wetlands is fire disturbance (Comer 1996; Kost 2004). Over the past 150 years, humans have directly and indirectly altered the natural fire disturbance regime in northern Lower Michigan. Humans directly influence fire regimes by fire ignition and suppression and indirectly through climate change, altered vegetation, timber harvest, and land development (Sturtevant et al. 2004). There has been drastic human influence on the fire regimes of the Grayling Subdistrict since the mid 1800s when settlers moved to northern Michigan for homesteading and logging. Widespread logging in the upper Great Lakes during the late 19th century provided the slash fuel for intense fires that burned a majority of the region. Human development in northern Michigan has also lead to rigorous fire suppression. As settlement has increased in the region, so has the suppression of wildfire to protect human interests. An efficient fire suppression policy has successfully reduced fire size and frequency, resulting in fire intervals that are an order of magnitude longer than historic fire regimes (Cleland et al. 2004). Simard and Blank (1982) report that the number of acres burned on the 415,000-acre Huron National Forest declined from 13,000 acres in the 1910s to 4,730 acres in the 1920s to 384 acres in the 1970s.

In the 1800s the Huron National Forest contained an estimated 205,000 acres of pine barren and dry sand prairie habitat for barrens species. Currently the Huron National Forest has an estimated 8% of its original pine barren habitat, and the current patches are small and highly isolated (USDA Forest Service 2005a). This drastic decline in pine barren and sand prairie acreage is primarily a result of fire suppression. Cleland et al. (2004) report the historical (1836–1858) fire rotation for jack pine–dominated, dry outwash plains with coarse-textured soils was 59 years. The modern (1985–2000) fire rotation for this same ecosystem is estimated to be 787 years, 13 orders of magnitude longer than historic estimates (Cleland et al. 2004). The amount of jack pine–dominated, dry outwash plains with coarse-textured soils burned in this historic fire regime class decreased from 85,420 ha during 1836–1858 to 6,296 ha during 1985–2000 (Cleland et al. 2004). Without frequent fires, woody vegetation can encroach into open areas, enabling the succession of jack pine barrens to dense jack pine forests. Subsequently, the 100-plus years of fire suppression in the region has lead to an increase in the number and density of trees and shrubs in natural systems. As a result, if and when fires do occur they may burn at an increased intensity as compared to fires that occurred prior to European settlement.

Many wetlands in the Grayling Subdistrict are embedded within or adjacent to fire-prone uplands. As a result, these wetlands historically may have burned as fires from nearby uplands moved across the landscape. Cleland et al. (2004) report that the fire regime of fire-prone wetlands has been drastically altered from a return interval of 120 years to one of 5,882 years. The researchers attribute this dramatic increase in the fire rotation to the effective suppression of fire in adjacent uplands and an increase in fire-resistant deciduous tree species. Without occasional fires in wetlands, woody vegetation can invade and tree species composition can shift, changing the overall dynamics of the wetland systems.

Altered fire regimes in jack pine barrens and dry sand prairies also poses a threat to the native species that evolved in the presence of frequent fires, many of which are the nested target species of our conservation plan. In particular, plant species with fire-dependent or fire-resistant adaptations that once provided them with a competitive advantage in fire-prone habitats are threatened by altered fire regimes. Without frequent fire, woody and nonnative species are able to outcompete these native species. For example, Taylor (1990) indicates that Alleghany plum *(Prunus alleghaniensis* var. *davisii)* is a clonal, shade-intolerant plant that will decline if shaded by more than 50%. Historically, fire created and maintained the sunlit openings required for its survival. Currently, Alleghany plum is considered a species of special concern primarily due to loss of appropriate habitat through forest succession (Higman et al. 1996d). Pale agoseris *(Agoseris glauca)*, rough fescue *(Festuca scabrella)*, and Hill's thistle *(Cirsium hillii)* are also threatened by the reduced light availability that results from canopy closure in the succession of open prairies, savannas, and jack pine barrens (Higman et al. 1996a; Higman et al. 1996b; Penskar 1997). Increased litter accumulation, a result of infrequent fire, also contributes to poor seedling establishment of Hill's thistle (Higman and Penskar 1986).

The vegetative succession of open communities such as jack pine barrens and dry sand prairies that has resulted from fire suppression also poses a threat to the eastern massasauga rattlesnake *(Sistrurus catenatus catenatus).* The eastern massasauga's complex habitat requirements include open sites that are intermixed with shaded areas for thermoregulatory purposes (Szymanski 1998). Additionally, gravid female massasaugas tend to select open, barrens-like habitat. In a radiotelemetry study conducted in Pennsylvania, gravid females exhibited a strong preference for open dry sites and were found basking in close proximity to one another (Reinert and Kodrich 1982). It has been suggested that gravid females may regulate embryonic development through thermoregulation and they require open habitat for basking in the sun (Kingsbury 2005; Szymanski 1998). Therefore, the maintenance of open, early successional habitat through fire disturbance is important for the conservation of Grayling eastern massasauga habitat.

Roads

Roads pose a very high-level threat to target community types and species, particularly eastern massasauga populations. Over the last 100 years, continued human pressure in the Grayling Subdistrict has spurred development and associated road building, which has fragmented the landscape. In the Huron National Forest alone, there are approximately 1,638 miles of maintained roads, representing a density of approximately 1.51 miles of road per square mile (USDA Forest Service 2002). Approximately 174 miles of these roads are maintained by the Forest Service, while the rest are maintained by counties. The following threats are attributed to roads (USDA Forest Service 2002):

- Erosion and runoff which reduce soil and water quality

- Impediment of natural water flow from adjacent streams and rivers and filling in wetlands
- Increase in nonnative invasive species
- Fragmentation of landscapes and creation of edge habitats through former forest interior
- Microclimate changes due to increased heat retention properties of pavement
- Localized reduction in the ability of fish to move along streams and rivers
- Facilitation of access to private lands
- Increase in noise disturbance to wildlife and recreational users

Of these impacts, one of the most difficult to reverse is the increase in invasive species, including invasive plants, insects, and animals, such as the brown-headed cowbird *(Molothrus ater)* that parasitizes the nests of the federally endangered Kirtland's warbler. However, roads also provide access to aid in the treatment of pests and diseases and to aid in fire management, but this access also leads to the probability of increased development on private lands (USDA Forest Service 2005b).

As identified by the Forest Service, fragmentation imposed by roads presents a barrier to plant dispersal and animal migration and creates unnatural firebreaks in the landscape. In addition, roads frighten wildlife, limit species mobility, and increase mortality of migrating species such as the eastern massasauga and Blanding's turtle *(Emys blandingii)* (Kingsbury 2005). Eastern massasaugas will not cross a paved road, leading to severe population fragmentation (Kingsbury 2005). Roads can also isolate vulnerable insect populations, particularly species with short flight distances, resulting in local extinctions and decreased population viability.

Logging and Timber Plantations

Timber production has been an integral part of Michigan's past and continues to be important to the state's economy and cultural identity. In the past, logging altered the composition of jack pine barrens by selectively cutting the large diameter red and white pines *(Pinus resinosa* and *P. strobus)* that comprised the supercanopy of this community type (Kost et al. 2000). Today, over half of the land in Michigan is considered timberland (MI DNR 2004). Timber plantations pose a very high-level threat to jack pine barrens and dry sand prairies as many former jack pine barrens sites have been converted to pine plantations and continue to be managed as such (MI DNR 2005b). Most historic prairies are also managed as pine plantations on public lands. The Michigan Natural Areas Council set aside 440 acres of dry sand prairie in 1964 but it has all been appropriated for plantations (Chapman 1984). The restoration of jack pine barrens and dry sand prairies will require returning a portion of these plantations into ecosystems with similar composition, structure, and functions that occurred in pre-European settlement.

Logging is also a low-level threat to the secretive locust *(Appalachia arcana)* as this disturbance may affect oviposition sites (Rabe et al. 1996). Although little is known about the specific habitat requirements of the secretive locust, studies suggest that the locust may lay its eggs on the twigs of shrubs or trees. Rabe et al. (1996) suggest that logging near wetlands or known occurrences of the secretive locust should be avoided.

Development

As northern Lower Michigan was settled, the open setting of former barrens and prairies were often selected for homestead and grazing sites. Since European settlement, development in the region has gradually increased, particularly second-home and tourist-based development in the last 40 years. In general, increased human pressure and development in the Grayling Subdistrict pose a high-level threat by contributing to fire suppression efforts to protect property interests, the introduction and abundance of invasive species, the reduced size and fragmentation of natural communities, and altered hydrologic regimes, all of which are stresses to the conservation targets.

Kirtland's Warbler Management Areas

The current Kirtland's warbler *(Dendroica kirtlandii)* management approach poses a high-level threat to target communities and species. The *Kirtland's Warbler Recovery Plan* dedicated 127,600 acres of publicly owned lands for the benefit of the warbler (Byelich et al. 1985). To date, the agencies involved in the recovery effort have established 24 management areas across 150,000 acres of public land (USDA Forest Service 2005a). The recovery plan required that 38,000 acres of breeding habitat is maintained at all times (Byelich et al. 1985). The agencies involved in the recovery effort currently must maintain jack pine plantations to create the specific habitat requirements of the warbler. The primary technique used by the Forest Service and the MI DNR to create this habitat is to clearcut 200 acre or larger stands of jack pine on a 50-year rotation followed by mechanical or hand planting of 2-year-old jack pine seedlings. Approximately 25% of each site is left unplanted to mimic the natural openings created by fire (Houseman and Anderson 2002). These Kirtland's warbler management areas or plantations are essentially monocultures of jack pine which fail to mimic the natural jack pine dominated communities that historically supported the Kirtland's warbler. Additionally, with the exception of the small areas left unplanted in each plantation, Kirtland's warbler management areas do not provide the open conditions required by many pine barren and prairie species.

In addition, Kirtland's warbler management areas have often been sited on the landtype associations that historically may not have supported jack pine systems and the agencies are instructed to protect the management areas from fire (MI DNR 2005b; USDA Forest Service 2005a). As a result, the management areas provide habitat for warbler but do not mimic the dynamic fire-dependent jack pine communities that historically supported an array of species. Kashian and Barnes (2000) suggest that a landscape ecosystem-based approach to Kirtland's warbler management would prolong the warbler occupancy of a management area and provide a more holistic approach to conservation.

Since the inception of the *Kirtland's Warbler Recovery Plan*, evolving research has demonstrated that the bird prefers larger blocks of habitat, and the territory required by each male bird is actually 38 acres as opposed to the 30 acres as originally believed (USDA Forest Service 2005a). As a result, the Forest Service plans to increase the size of the treatment blocks and the total number of acres dedicated to the Kirtland's warbler from 109,000 acres of essential Kirtland's warbler habitat to 135,965 acres. The larger treatment blocks will also make it easier for the agency to manage for the warbler. Other partners involved in the recovery effort will be expected to increase the size and extent of their management areas based on these recent research findings. The intensive management used to establish and maintain Kirtland's warbler treatment blocks requires a large time and resource commitment on the part of the agencies involved. The UDSA Forest Service (2005a) states that "habitat management has been costly, but

extremely successful." As the Forest Service and partner organizations increase the size and extent of the Kirtland's warbler management areas, it will be necessary to commit additional public acres and dollars to single-species management.

In addition, the potential for implementing the North Camp Grayling Pine Barrens Management Plan is currently delayed over concerns that restoration of jack pine barren community will attract the endangered songbird, thereby limiting the capacity of the Michigan Department of Military Affairs to conduct training operations at the camp (Jacobs 2005).

Increased Predation by Raccoons

Raccoon predation is considered a high-level threat to the survival of Grayling Subdistrict turtle populations, specifically the wood turtle *(Glyptemys insculpta)* and Blanding's turtle *(Emys blandingii)* (Harding 2006). Raccoons are opportunistic omnivores that have adapted to and thrived in the human-dominated landscape. As a result, raccoon populations have greatly expanded since the turn of the century (Fox 2001). The expansion of raccoon populations has placed increased pressure on their prey. Nest predation of wood turtle eggs can exceed 80%, and raccoons are often the primary predators (Harding 1997 in Lee 1999). At a wood turtle research site in the Upper Peninsula of Michigan, Harding (2006) anecdotally reports raccoon predation of turtle eggs and adult turtles.

Poaching

Overall poaching is a high-level threat to several target species in the Grayling Subdistrict including the eastern massasauga, wood turtle, and Blanding's turtle. In general, the collection of eastern massasaugas for the pet trade can be a considerable threat to the species (Kingsbury 2005; Szymanski 1998). Recent cases in Illinois and Indiana demonstrate that wild massasaugas are being collected and sold for a profit (Szymanski 1998). Massasaugas, especially gravid females who are basking in open areas, are attractive to poachers because they are small and easy to locate. Poachers range from individuals who collect snakes for personal pets to those who collect snakes to sell for profit. Poaching can also spread disease and alter the genetics of snake populations (Kingsbury 2005). As with many reptile populations, annual adult survivorship is essential to maintaining a minimum viable population and any poaching of adults, especially gravid females, can have detrimental effects on an entire population. A population viability analysis for an eastern massasauga population showed that a minimum of 83% of a massasauga population must persist in order to maintain a stable population (Seigel 1994 as cited in Szymanski 1998).

Collection for the pet trade also poses a significant threat to Grayling Subdistrict turtle populations, especially the wood turtle. Wood turtles are highly targeted by the pet trade since they have a reputation as intelligent, engaging pets. Additionally wood turtles are easy to locate and pick up as they are limited to river corridors (Harding 2006). Poaching for the commercial pet trade and incidental collecting by the general public are considered the main reasons that Michigan's wood turtle populations have declined significantly over the past 20 to 30 years (Lee and Legge 2000). Blanding's turtles are often incidentally taken in traps set out for snapping turtles or collected by poachers searching for wood turtles (Harding 2006).

Disking and Mowing
The land management practices of disking and mowing pose a medium-level threat to the eastern massasauga (USFWS 2005). Mowing and disking during the snakes' active season may cause direct mortality to the snakes as they can not move fast enough to avoid the mechanical blades.

Injury and Premature Death Due to Human Persecution
Overall, indiscriminate killing by humans is a medium-level threat to the eastern massasauga. Bounty hunting was once encouraged in counties within Illinois, Indiana, Minnesota, and Wisconsin (Szymanski 1998). Intentional human persecution of eastern massasaugas continues today, especially as human development and encroachment into previously unoccupied habitats continues to escalate. This leads to an increased number of human- snake encounters, which often result in massasauga mortality. This practice is fueled by a fear of snakes, particularly venomous species, and a lack of understanding of the minimal threat posed by the massasauga (Kingsbury 1996). The dynamics of massasauga populations are such that small increases in adult mortality may have severe impacts on the overall population.

Off-Road Vehicles (ORVs)
Illegal ORV ridership poses a medium-level threat to several Grayling target communities and species. An assessment of Michigan ORV trails conducted by the MI DNR noted illegal ORV uses on 44 (54%) of the trails/routes assessed. In the Lower Peninsula, illegal uses include "illegal scramble areas and hill climbs, riding in wetlands or river/lake shorelines and riding non-street licensed ORVs on county and state roads, especially near campgrounds" (Nelson 2005b). One concern is that by restoring open jack pine barrens and dry sand prairies in the region, illegal ORV use in these areas may increase (USDA Forest Service 2005a). Off-trail ORV use can lead to soil compaction and erosion, destruction of sensitive plant populations, introduction of invasive species, and undue stress to wildlife populations (Penskar 1997). Houghton's goldenrod *(Solidago houghtonii)* is threatened by development and recreational activities, particularly ORV use. In addition, ORV trails fragment habitat, contributing to the increased isolation and vulnerability of plant and insect populations.

On the advice of Michigan State University, MI DNR recently conducted a review and revision of the state ORV plan. The plan calls for increased patrol and enforcement to combat illegal ORV activity.

Inappropriate Prescribed Fire
Inappropriate prescribed fire is a low-level threat to several target species. Although species such as the eastern massasauga require open patchy habitat created and maintained by fire, poorly planned or intensive prescribed burning can cause undue mortality to plant and animal populations. Prescribed burns, conducted during the eastern massasauga's active season (late April to October), can kill snakes that are unable to move fast enough to avoid the fire (Kingsbury 2005; Szymanski 1998). This mortality can impact already stressed massasauga populations. Most land managers prefer to burn in the spring or fall when vegetation is dry enough to carry a fire. Unfortunately, this timeframe overlaps with the period when snakes are either emerging from or entering their hibernacula and are most vulnerable (Kingsbury 2005). In addition, insect populations such as the dusted skipper and blazing star borer may be adversely affected by excessive prescribed burning of prairies and barrens habitats (USDA Forest Service

2005a). The negative effects of prescribed fire can be exacerbated by the fragmented nature of many Grayling insect populations, where isolated populations may be unable to recover. Spring burns may also inadvertently damage the growth of cool-season grasses such as rough fescue, which is most productive in early to late spring (Higman et al. 1996c).

Pesticides and Herbicides

A low-level threat to target plant species in the Grayling Subdistrict is the misapplication of pesticides and herbicides. Of particular concern is the unintentional application of herbicide to Hill's thistle because it may be confused with numerous nonnative thistles (NatureServe 2006b). In addition, plants that have been able to persist in openings created along roadsides and power line rights-of-way, such as Allegheny plum, are also vulnerable to herbicide application and highway construction projects (Taylor 1990). In addition, sensitive insect populations such as the ebony boghaunter may be affected by pesticides and broadcast toxic pollution (NatureServe 2006b).

Part III: Methods, Results, and Discussion

Chapter 9: Strategies

We identified the following objectives and associated strategic actions to guide The Nature Conservancy's (TNC) future conservation actions in the Grayling Subdistrict. Table 1 provides an overview of the objectives that are described in this chapter. As many of the objectives and strategic actions are linked we cross-reference them by the numbers listed in the table. In drafting these strategies our aim was to be as specific and thorough as possible. Where appropriate, we have included information on next steps and contact information for the benefit of Conservancy staff in initiating the implementation of this plan.

Table 1. List of recommended objectives for The Nature Conservancy in the Grayling Subdistrict.

Objective 1	By December 2006, initiate the implementation of this plan.
Objective 2	By 2008, establish a collaborative working group with agency personnel, private landowners, and other stakeholders to address threats and ensure the conservation of targets.
Objective 3a	By 2030, achieve a "good" ranking for fire regime in jack pine barrens, dry sand prairie, and wetlands of the Grayling Subdistrict, as defined in the viability analysis.
Objective 3b	By 2020, ensure that at least 12,000 acres of jack pine barrens and 600 acres of dry sand prairie are restored across the Grayling Subdistrict.
Objective 4a	Support and/or undertake additional research on the species and ecosystems of the Grayling Subdistrict.
Objective 4b	By 2010, partner with at least 3 organizations to provide environmental education and outreach to aid the conservation of the Grayling Subdistrict communities and rare species.
Objective 5a	By 2010, ensure the protection of the high quality wetlands at Camp Grayling including the mesic sand prairie wetland complex (Portage Creek-Howes Lake Complex) with populations of *Solidago houghtonii.*
Objective 5b	By 2015, decrease the threat level of incompatible land management practices on *Sistrurus catenatus catenatus.*
Objective 6a	By 2010, ensure the protection of isolated wetlands less than 5 acres in size on private and public lands.
Objective 6b	Reduce the negative impacts of roads and development on the targets.
Objective 6c	Work with the MI DNR to reduce the impact of illegal ORV use on public lands.

Objective 1: Implementation
By December 2006, initiate the implementation of this plan.

This obvious first step must take place quickly for any of the other objectives to be met in a timely manner. Three strategic actions must be taken immediately.

Strategic action: Secure funding for two years to initiate the implementation of the plan.

It is important to secure funding as soon as possible to cover the staff time and any other expenses related to initiating the conservation plan.

Strategic action: Hire a staff person to coordinate the implementation of this plan and identify future funding sources.

Ideally, a new, additional staff member will be fully devoted to implementing this plan. Hiring a staff person will increase the likelihood that the plan is fully carried out, as it will require considerable amounts of time, funding, and other support. This person will also be able to build on this plan and link it to other conservation plans and activities in the Grayling Subdistrict. A staff coordinator will serve as a central contact person regarding all of the issues in the subdistrict. The new staff person will need to develop relationships with the various stakeholders and facilitate greater communication among them. The staff person will need to secure funding and identify future opportunities to ensure that this work can continue. Long-term financial planning will be necessary because of the long time frame of the plan—some goals may not be reached until 2030.

Strategic action: Conduct a scoping meeting with stakeholders to refine how TNC can work with them.

This meeting is particularly important since TNC currently does not own any land in the Grayling Subdistrict. TNC must rely fully on the cooperation of land managers, owners, and users for carrying out the conservation plan. Because the Grayling Subdistrict is so large, with so much public land, TNC will still need to work closely with stakeholders even if land is acquired for conservation purposes. This initial meeting will help clarify what stakeholders are willing to support and capable of doing, as well as what their needs are. The information gathered at this initial meeting can be used to further refine the objectives and strategic actions in this plan. The key stakeholders to include are the MI DNR and USDA Forest Service, but local nongovernmental organizations (NGOs) and private landowners should be included as well.

Objective 2: Collaboration
By 2008, establish a collaborative working group with agency personnel, private landowners, and other stakeholders to address threats and ensure the conservation of targets.

Due to the patchwork of land ownership in the Grayling Subdistrict, collaboration is essential to conservation of the targets identified in this plan. To ensure a cohesive, coordinated conservation effort across the Subdistrict, our project team envisions the inception of a Grayling regional working group or Grayling partnership. This alliance would include agency staff from the Huron-Manistee National Forests, MI DNR, Camp Grayling Military Reservation, Michi-

gan Natural Features Inventory, TNC, and the Stewardship Network. In addition, the working group or partnership may include staff from the U.S. Fish and Wildlife Service, other NGOs (as discussed in chapter 4), and private citizens.

The specific goals and activities of this working group or partnership will need to be clearly defined by the stakeholders and TNC staff. In a general sense, we imagine the working group would adopt some of the objectives set forth in this plan such as: setting subdistrict-wide restoration goals for jack pine barrens and dry sand prairies; annual acreage targets for prescribed fire; and joint research initiatives. The working group could jointly apply for funding, share resources such as a roving burn and restoration crew, and exchange lessons learned from restoration projects.

In developing this partnership, The Nature Conservancy of Michigan can emulate the efforts of the Border Lakes Partnership in Minnesota. The Border Lakes Partnership is an interagency team of natural resource professionals from the USDA Forest Service North Central Experiment Station, Superior National Forest, Minnesota DNR, Voyageurs National Park, Quetico Provincial Park, and The Nature Conservancy of Minnesota whose aim is to "develop collaborative, cross-boundary strategies for timber production, hazard fuel reduction, and biodiversity" (TNC 2004a). The Border Lakes landscape is similar to the Grayling Subdistrict in that it covers a large area (approximately 5 million acres) and is comprised of various land ownership. The Border Lakes Partnership identifies the following as benefits of a collaborative approach (TNC 2004a):

- Inform the Border Lakes conservation plan
- Assist with developing a fire regime condition class map assessment
- Leverage funds from the Healthy Forest Initiative and the National Fire Plan
- Opportunities for collaboration and resource sharing
- Potential to inform management decisions made through NEPA

The Partnership has received limited funding through the National Fire Plan and The Nature Conservancy's Fire Learning Network to coordinate these efforts (TNC 2004a). Contact information for the Border Lakes Partnership is provided in appendix C. If The Nature Conservancy of Michigan chooses to initiate a Grayling working group it may be beneficial to contact members of the Border Lakes Partnership for advice and guidance on building a multi-stakeholder partnership.

Strategic action: By 2007, conduct two initial meetings to gauge interest in establishing a working group.

This strategic action will build on the initial scoping meeting detailed in objective 1 and may be dependent on the hiring of a TNC staff person or identifying an alternate lead person and/or agency to launch the Grayling working group. We suggest the Conservancy conduct these scoping meetings within the next year to build on the momentum generated by the research of this plan, the new Huron-Manistee National Forests Management Plan, and the sustainable forestry certification for MI DNR forest system. A list of persons contacted in the drafting of this plan is provided in appendix C. This list represents a starting point for individuals to invite to such a scoping meeting.

Strategic action: By 2008, draft key goals and objectives of the Grayling working group.

Based on the interest and commitment level generated by the scoping meetings, we suggest the Conservancy and its partners solidify the goals, objectives, activities, and responsibilities of the working group by 2008.

Objective 3a: Fire
By 2030, achieve a "good" ranking for fire regime in jack pine barrens, dry sand prairies, and wetlands of the Grayling Subdistrict, as defined in our viability analysis.

Strategic action: Develop regional fire management plan with annual acreage goals for the Grayling Subdistrict.

This action would be best suited as an activity of the Grayling working group described in objective 2. The development of a regional fire management plan would allow TNC and partners to set subdistrict-wide goals for prescribed fire and annual benchmarks by which to measure success. It would also facilitate inter-agency cooperation and resource sharing. The Loess Hills Project in Iowa provides an excellent example of a multiple landowner landscape scale fire management plan. A draft copy of the plan is available through the Great Plains Fire Learning Network and available on-line at http://tncfire.org/training_usfln_GPfln.htm.

Strategic action: Develop a Memorandum of Understanding or mutual agreement with the USDA Forest Service and the MI DNR to allow for personnel to conduct prescribed fires across land ownership boundaries.

This action is closely tied with the previous action of establishing a regional fire management plan and the subsequent action of jointly hiring a roving fire crew for the subdistrict. The will of stakeholders to work together must be tied to their ability to share resources. Since most agencies require personnel to complete standardized USDA Forest Service fire training, a majority of fire personnel are already qualified to conduct prescribed fire on multiple lands. The MOU will provide the administrative framework for agencies to leverage their resources and increase the on-the-ground implementation of prescribed fire.

Strategic action: Increase the short-term capacity for prescribed fire by hiring a seasonal fire crew and increase long-term capacity by recruiting and training local people in prescribed fire.

Currently each public agency relies on their respective staff and resources to conduct prescribed fire on their lands. Additionally there are few prescribed fire private contractors in the Grayling region (MI DNR 2005b). The lack of contractors poses a logistical problem to the on-the-ground application of prescribed fire, particularly on private lands. Brian Piccolo reports that the Landowner Incentive Program has encountered difficulty finding contractors to conduct prescribed fire, as most have to travel long distances and are therefore difficult to coordinate. Due to unpredictable weather conditions, fire practitioners often need to be readily available as they must conduct prescribed burns when weather conditions are appropriate. To increase the short term capacity of implementing prescribed fire in the subdistrict, a roving seasonal fire crew would be "on call" to conduct prescribed burns on federal, state, and private

lands during the spring and fall burn season. The effectiveness of this roving crew is contingent on previous strategic action of developing a Memorandum of Understanding with the USDA Forest Service and MI DNR to standardize the training, certification, and permissions required for personnel to conduct prescribed burns across landownership. This fire crew would also require a host organization, burn boss, and fire coordinator.

In conjunction with the hiring of a roving fire crew, the Conservancy and the Grayling working group could focus on recruiting, training, and building the capacity of local fire practitioners. One place to start would be with local fire departments and volunteer fire fighters. Perhaps in cohort with the Landowner Incentive Program, The Nature Conservancy and the Grayling working group could sponsor fire training workshops in the region and develop an incentive program to encourage local fire practitioners to attend.

A potential model for an inexpensive roving fire crew and training program is the UW Stevens Point Fire Crew, a student run organization at the University of Wisconsin Stevens Point. This Fire Crew of 130 students is involved in fire suppression and prescribed fire activities on private and public lands in Wisconsin and beyond. The group works closely with the Wisconsin DNR and often helps coordinate fire training opportunities in Stevens Point (University of Wisconsin Stevens Point 2004). The student group has also traveled to Florida to assist in prescribed fire activities on Department of Defense lands and worked in conjunction with the US Fish and Wildlife Service, USDA Forest Service, and The Nature Conservancy. The Crew works mainly on a volunteer basis in exchange for donations and the costs of transportation and lodging. Additionally the Crew has been paid on an individual basis in working with the USDA Forest Service (Schmidt 2006). This arrangement provides hands-on experience for students and inexpensive, flexible assistance for the agencies. A similar student Fire Crew at a university in Michigan could increase the number of qualified fire personnel in the state leading to an increase in the amount of prescribed fire. The Conservancy may chose to contact professors at natural resource programs in Michigan to initiate such a program.

Strategic action: Encourage the Michigan Prescribed Fire Council to hold their annual meeting in the Grayling Subdistrict and conduct a demonstration burn at Camp Grayling.

The mission of the Michigan Prescribed Fire Council is to "protect, conserve, and expand the safe use of prescribed fire on the Michigan landscape" (Michigan Prescribed Fire Council 2006). Annually, the Council hosts a two-day workshop to bring together prescribed fire practitioners from across the State. In 2005, the workshop was held in Kalamazoo, MI. Topics at the annual meeting included presentations on fire ecology, natural community ecology as impacted by fire, effects of fire application at the landscape level and how this might be accomplished in a safe and productive manner. Also included were field trips to Fort Custer Military Training Center to view prescribed fire treatment areas. Encouraging the Michigan Prescribed Fire Council to host its annual meeting in the Grayling Subdistrict would bring statewide attention to the importance and increasing application of prescribed fire in the Grayling Subdistrict. The meeting could also network a fairly well-organized group of prescribed fire personnel from southern Michigan with the burgeoning network of prescribed fire personnel in northern Michigan. If the Council agrees to host it annual meeting in the Subdistrict, Camp Grayling or a private Landowner Incentive Program site would make excellent locations to visit on field trip.

Strategic action: By 2008, use LANDFIRE data to prioritize recommendations for areas that need to be burned.

LANDFIRE is a multi-year wildland fire, ecosystem, and wildland fuel mapping project of the USDA Forest Service, the U.S. Geological Survey, and The Nature Conservancy. Once complete, it will provide consistent comprehensive data on existing vegetation composition and structure, historical vegetation conditions, and historical fire regimes (LANDFIRE 2006). The LANDFIRE data for the state of Michigan is set to be complete in 2008. These data will allow the Conservancy and its partners to assess the pre-settlement fire patterns in the Grayling Subdistrict and use this knowledge to guide future work in the subdistrict. The Conservancy should also ensure the MI DNR incorporates this data into the Ecoregional Plan for the northern Lower Peninsula.

Strategic action: By 2010, identify a site-based project in the Grayling Subdistrict to include in the regional Laurentian Mixed Forest U.S. Fire Learning Network.

In 2002, The Nature Conservancy, the U.S. Department of Agriculture and the Department of the Interior launched a program titled *Restoring Fire-Adapted Ecosystems* in an effort to restore the severely altered fire regimes in U.S. forests and grasslands. The program included three main components – 1) the U.S. Fire Learning Network; 2) the U.S. Fire Training Program; 3) U.S. Wildland Fire Education Program (TNC 2006f). The Fire Learning Network (FLN) is a collaborative, multi-stakeholder learning network that aims "to support and accelerate collaborative, community-based, landscape scale fire management planning and implementation through the use of regional and national workshops" (Fulks 2004). The FLN involves multiple stakeholders in a collaborative process as a long term approach to overcome barriers in restoring the natural role of fire (TNC 2006e). The FLN was first created in 2002 and consisted of a single national network. The second phase (2004-2006) of the FLN is focusing on establishing regional networks as a part of the national network. The regional networks receive the support and guidance of The Nature Conservancy's Global Fire Initiative Staff.

There are currently eight regional learning networks in the United States. One of these regional networks is the Laurentian Mixed Forest Fire Learning Network. This regional network includes a small group of projects and collaborators from Minnesota, Wisconsin, and Michigan's Upper Peninsula (TNC 2006e). There are currently two projects in Michigan's Upper Peninsula that are a part of the Laurentian Mixed Forest Network – the Muskrat Lakes/Two Hearted River Watershed and Shakey Lakes. The Muskrat Lakes/ Two Hearted Watershed encompasses 115,000 acres that supports uplands of mature red and white pine forests, and northern hardwoods such as sugar maple, red oak, and beech. Shakey Lakes is oak-pine barren site located in the southern Upper Peninsula.

A site in the Grayling Subdistrict could potentially benefit from inclusion in the Laurentian Fire Learning Network as it would provide the new Grayling project with support and guidance from the Global Fire Initiative and the Regional Network as well as training and networking opportunities.

To further pursue this option TNC staff should contact the Laurentian Forest Fire Learning Network in order to stay abreast of the Network's status and future plans. We suggest soliciting the opinion of the Fire Learning Network coordinator on whether or not a Grayling Subdistrict site would benefit from inclusion in the FLN. If so, then the Grayling project manager would

need to identify a suitable site within the Grayling Subdistrict and take the appropriate steps to include it in the Laurentain FLN.

Objective 3b: Restoration
By 2020, ensure that at least 12,000 acres of jack pine barrens and 600 acres of dry sand prairie are restored across the Grayling Subdistrict.

This objective is closely tied to objective 3a, since jack pine barrens and dry sand prairies are dependent upon fire. Their restoration will be linked to the reestablishment of a more natural fire regime.

We chose acreage as the focus for this objective because size is a commonly used method to evaluate the current status of an ecosystem and its change over time. Setting restoration or protection goals based on a percentage of the historic distribution of a species or ecosystem is also a common conservation technique. There were an estimated 120,000 acres of jack pine barrens in the Grayling Subdistrict circa 1800 (Comer et al. 1995). As the current extent of jack pine barrens amounts to less than one percent of the historical acreage, we assigned the current rating for this indicator as "poor" in our viability assessment for jack pine barrens (described in chapter 6). We chose 10 percent of the historic (1800) distribution, which would be 12,000 acres of jack pine barrens, as the goal for restoration by the year 2020. We estimate that this would improve the ranking from "poor" to "fair." We think a "fair" ranking of 12,000 acres by 2020 is an achievable goal that would represent a marked improvement over the current situation. Furthermore, we think that a "good" ranking for this indicator would be 25% of historical acreage or 30,000 acres of jack pine barrens in the Grayling Subdistrict by 2040.

Similarly, we ranked dry sand prairies as "poor" because they currently occur on less than one percent of their historical acreage in the Grayling Subdistrict—approximately 6,000 acres in 1800 (Comer et al. 1995). We think an achievable goal would be to restore 600 acres of good quality dry sand prairie by 2020, which is 10 percent of the historic acreage and would be a significant improvement over the current situation. This would improve the size ranking of dry sand prairies from "poor" to "fair". A "good" ranking for the size indicator for dry sand prairies would be 25% of historical acreage, or 1500 acres by 2040. These numbers are benchmarks by which TNC can assess restoration progress in the Grayling Subdistrict. TNC should continually evaluate these metrics and adjust the rankings in light of evolving information and restoration progress in the subdistrict.

There are four strategic actions related to achieving this objective.

Strategic action: Position TNC staff to become an integral part of the ecoregional plan development for northern Lower Michigan by the end of 2007.

As a part of the sustainable forestry certification process the MI DNR will be developing an Ecoregional Plan for the northern Lower Peninsula by December 2007. The plan will address issues such as biodiversity, rare communities, federal and state threatened and endangered species, species of special concern, prescribed fire, land acquisition and disposal, and illegal ORV use. The 17-member Northern Lower Peninsula (NLP) Eco-Team is leading the process to develop the Northern Lower Peninsula Ecosystem Management Plan. They are "committed to the fair and responsible management of resources in the Northern Lower Peninsula" (MI DNR

2005d). The NLP Eco-Team has held a series of focus groups and public meetings to gather information on the public's values and concerns regarding natural resource management, and they continue to solicit public input in the development of the plan (MI DNR 2005c). The work instructions put forth by MI DNR for development of the Ecoregional Plan encourage collaboration with external parties such as TNC, MNFI, and the USDA Forest Service. This process would be an excellent opportunity for TNC to get more involved with resource management in the northern Lower Peninsula. It is a particularly good opportunity to ensure that restoration of jack pine barrens and dry sand prairies and the protection of wetlands are considered in the MI DNR's Northern Lower Ecosystem Management Plan.

Strategic action: Using historical distribution and fire data, identify potential areas for jack pine barrens and dry sand prairie restoration.

Identifying the historical distribution of jack pine barrens and dry sand prairies and evaluating it alongside other factors—including fire data—will serve as a useful step towards actual restoration work in the Grayling Subdistrict. This strategic action assumes that the historical distribution of an ecosystem is one predictor of its potential current distribution, because the underlying physiography, soils, and climate are unlikely to change quickly. Landtype association and fire frequency are other key predictors of the ecosystems that can be supported in an area. It is important to site restored barrens and prairies where the appropriate landforms, soils, and climate occur and where they were historically located—while recognizing that these ecosystems were dynamic, patchy, and disturbance-driven in the past.

Geographic Information Systems (GIS) analysis will serve as a useful tool for identifying areas for potential restoration (and preservation). The USDA Forest Service, MI DNR, MNFI, and TNC may have conducted similar analyses, so it might be useful to consult with them regarding this particular idea to find out what has already been done. The project team has conducted a preliminary analysis of potential pine barrens (and wetlands), which may be of use to TNC in carrying out the conservation plan. We assessed the historical distribution of jack pine barrens and dry sand prairies using MNFI's land use circa 1800 data layer. We then compared this to current vegetation and land use and the extent of change in vegetation between 1800 and 2000. The result was a new set of layers depicting areas that had historically been pine barrens or prairies and have similar vegetation today. See Chapter 7 for detailed GIS methodology and appendix D for sample maps. The assumption underlying this analysis was that areas historically supporting these ecosystems, with similar vegetation today, would be more restorable than areas that experienced drastic changes in vegetation and land use. We recommend using this technique and analyzing the results alongside other factors—particularly current land use and ownership, and fire data—to assist in prioritizing areas for restoration and preservation. This strategic action complements the LANDFIRE action listed under objective 3a, Fire.

Strategic action: Work with Brian Piccolo and other LIP program administrators to encourage local private landowners to restore jack pine barrens and other ecosystems in the Grayling Subdistrict.

The Landowner Incentive Program (LIP) is jointly funded by the MI DNR and U.S. Fish and Wildlife Service and provides private landowners with advice, management plans, and technical and financial assistance to enhance, restore, and protect habitats for species at risk (MI DNR 2004a). In the northern Lower Peninsula, the program focuses on barrens and jack pine habitats and the management priority is to implement prescribed burns. This program comple-

ments objectives 3a and 3b of the conservation plan very well and TNC should capitalize on it quickly. TNC should work with Brian Piccolo and other LIP staff to discuss how TNC might help LIP succeed and grow.

The LIP faces several challenges that TNC might be able to address. Some are related to convincing landowners to use prescribed fire on their property and to the high cost of hiring contractors to carry out prescribed burns (MI DNR 2005b). Other challenges include high rates of absentee landowners, making it difficult for staff to communicate with them, and shrinking lot sizes, which reduce the size of potential restoration and prescribed burn sites.

Strategic action: Determine TNC's role in the implementation of the Camp Grayling Pine Barrens Restoration Plan.

A plan exists to restore and maintain jack pine barrens in an area within Camp Grayling. The MNFI produced the North Camp Grayling Pine Barrens Management Plan in 2000 to "serve as a catalyst and guide for creating and maintaining a functioning pine barrens ecosystem" (Kost et al. 2000). The proposed management area covers 5,120 acres and is currently managed for military training, wildlife habitat, forest products, and public recreation. The plan recommends reintroducing fire, replanting red and white pine, limiting soil disturbances, and preventing the spread of spotted knapweed. The MI DNR will be responsible for its implementation.

However, the plan remains on hold due to the possibility that Kirtland's warblers will move into the area as restoration progresses, which would disrupt military training activities (Jacobs 2005). The Army National Guard hopes to obtain an agreement to exempt their activities from the Endangered Species Act should warblers move into the area. In this case, the birds would not be counted as part of the Kirtland's warbler population and would be considered superfluous (Kost et al. 2000). TNC should work with Camp Grayling, MI DNR, USFWS, and MNFI staff to determine if and how TNC can help facilitate implementation of the plan.

Objective 4a: Research
Support and/or undertake additional research on the species and ecosystems of the Grayling Subdistrict.

Strategic action: Commission MNFI ecologists to conduct entomology studies on insects of concern in the Grayling Subdistrict.

The first step in undertaking this strategic action would be to secure funding in order to contract MNFI ecologists to conduct a multiple year inventory of the rare insects in the Grayling Subdistrict. Jointly funded research for such an inventory may be one of the actions of the Grayling working group. As indicated in the threats section (Chapter 8), a 2-year MNFI survey conducted at Camp Grayling collected 97 insect species, 11 of which are considered rare in Michigan, and two of which may be new to science. The report of this survey indicates the number of insects documented in each natural community closely paralleled the proportion of collecting effort within that community (Higman et al. 1994). This report exemplifies the notion that little is known because there are few surveys and research dedicated to them. This echoes the sentiment expressed by Dr. O'Brien in regards the lack of information on *Williamsonia* species in Michigan—little is known this genus because there is limited research on it. It

also highlights the need for additional research in order to craft effective conservation strategies for insect species in the Grayling Subdistrict.

Strategic action: Work with the University of Michigan Biological Station to facilitate student research of target species in the Grayling Subdistrict.

Each year hundreds of university students enroll in field based courses at the University of Michigan Biological Station (UMBS). Summer courses include Field Botany of Northern Michigan and Biology of Insects, among others. Additionally the UMBS Research Experiences for Undergraduates Program provides undergraduates students with "hands-on" experience, training, and guidance in planning and conducting primary research. The Nature Conservancy and/or the Grayling working group could potentially work with UMBS administration and faculty to set up appropriate field monitoring sites or research projects in the Grayling Subdistrict. This would provide a unique educational opportunity for the students and invaluable, inexpensive information on rare species of the Grayling Subdistrict. Additionally, The Nature Conservancy may consider refining its UMBS-TNC fellowship to allow students interested in conducting research on Grayling target species to apply for these research dollars.

Strategic actions:

- **Identify and/or purchase land that can be used as a demonstration area for ecosystem-based Kirtland's warbler management.**
- **Assist in funding a PhD or post-doctoral fellow to conduct research on ecosystem-based management for the Kirtland's warbler.**
- **By 2012, set up a demonstration Kirtland's warbler management area to determine the suitability of jack pine barrens and different jack pine planting patterns for the Kirtland's warbler.**

The 2005 Kirtland's Warbler Census counted a total of 1,415 singing males, well over the original goal set in the recovery plan of 1,000 (Carlson 2005). This success is the result of intensive and ongoing management efforts by government agencies in addition to the large amount of habitat opened up by the 1980 Mack Lake burn (USDA Forest Service 2005a). Currently Kirtland's warbler management areas are created by clearcutting and planting jack pines on a 50-year rotation (USDA Forest Service 2005). The plantings are done at a density of 4,510 trees/ha in rows that are 1.8 m apart, and the trees are 1.2 m apart within the rows (Probst and Weinrich 1993). They also leave about 25% unplanted in openings throughout the plantation (USDA Forest Service 2005).

We recommend these three strategic action steps for expanding Kirtland's warbler research in the Grayling Subdistrict. These steps focus on identifying and developing a research area to test if Kirtland's warbler management practices can be expanded to include other rare species and ecosystems. If successful, this area can be used as a demonstration to agencies and private landowners for new techniques in land management to ensure the stability of the Kirtland's warbler population along with conserving other rare and endangered populations and communities. Some of the experimental land management techniques could include reversing the current 75% cover / 25% open ratio to include more open space for prairie and barrens species, incorporate more prescribed fires, and altering the timing of burning and planting and successional growth on different landtype associations (LTAs, particularly those with frost pockets or cold air channels). TNC would need to find available land on appropriate LTAs, preferably near

other Kirtland's warbler management areas, and either purchase it or form an agreement with the owner to manage the land for an ongoing experiment lasting several decades.

In creating an experimental Kirtland's warbler management area, TNC should take into account the following recent research findings on the management of Kirtland's warbler and its habitat. In a landscape-level evaluation of management areas, Bocetti (1994) found that jack pine plantations and naturally burned areas had higher densities of male warblers than harvested stands. Plantations and wildfire areas were also similar in the clutch size and fledglings but had higher numbers of unmated males and fewer polygynous males. There was a slightly higher density of female warblers in wildfire sites. In addition, the physical similarities of plantations and wildfire sites included the sizes of the openings, physiography, and soils. The differences were the densities of jack pines and the groundcover composition. Plantations tended to have more sedge and lower jack pine density, while wildfire sites have more varied groundcover such as bearberry and blueberry and higher jack pine density. The warblers select areas with less sedge and less woody debris (Bocetti 1994). However, blueberries were not found to be a limiting factor in choosing a nest site—Kirtland's warblers are able to use a wide range of groundcover as long as it is similar in structure (Probst and Donnerwright 2003). Bocetti also stated that habitat should be managed to resemble burned areas, for instance by leaving woody debris on the ground after clearcutting so a prescribed burn would be hotter and cause more jack pine and shrubby groundcover regeneration (1994). Sedge species came back in lower amounts on burned sites than on unburned plantations (Houseman 2002). Mechanical disturbance is also effective in reducing the abundance of sedges through breaking mats and stimulating other groundcover plant growth (Probst and Donnerwright 2003). In addition, jack pines should be planted in clumps around more openings to promote both openings and density (Bocetti 1994). Managers should conduct prescribed burns and plant after three years so that blueberry can establish after the fire, but if they do not burn they should replant only one year after a fire (Houseman 2002). The openings created by fire and planting also leave space for important barrens species to colonize (Houseman and Anderson 2002). Plantations should also optimize size and occupancy length by finding sites and predicting the outcome of management based on the landform. Stands of 200 ha or greater can hold larger groups of warblers (Byelich et al. 1985). However, both large and small jack pine stands will hold more warblers for longer periods if they cover different landforms (Kashian and Barnes 2000). Therefore, the ideal habitat to conserve is not based so much on size as the physiography of the land.

Management is costly and time consuming and managers must consider the economic costs and benefits of each management procedure in addition to the species and habitat benefits. Mathematical models provide a framework for managers to determine the option that will minimize the cost while maximizing the probability of success (Marshall et al. 1998). Because a shorter rotation length of jack pine harvest means more stands in the younger age group and more habitat for warblers, the rotation length should be reduced to 39 years instead of the current 50 to maximize the number of breeding birds and minimize the cost of logging and timber sales (Marshall et al. 1998).

Objective 4b: Partnership

By 2010, partner with at least 3 organizations to provide environmental education and outreach to aid the conservation of the Grayling Subdistrict ecosystems and rare species.

An important strategy to address many threats in the Grayling Subdistrict is environmental education and outreach. As an international organization, TNC conducts many public education programs designed to increase the conservation of our natural ecosystems. We recommend that TNC use its internal resources and partner with outside organizations to increase the level of public knowledge about the special species and communities in the Grayling Subdistrict.

Strategic actions:

- **Assist the Stewardship Network in establishing a cluster in the Grayling Subdistrict.**
- **Work with partners to disseminate information on the role of fire in the natural ecosystems of the subdistrict.**
- **Work with the MNFI to disseminate information on *Sistrurus catenatus catenatus* to nature centers and other public recreational facilities.**
- **Work with partners to disseminate information on the impacts of collecting wild reptiles.**

Some relevant programs that TNC could implement in the Grayling Subdistrict and outside organizations TNC could partner with are listed below. Contact information, where available, for non-TNC organizations is also provided.

TNC Programs

Global Fire Initiative
As discussed in objective 3a, we suggest that TNC increase its involvement in restoring fire to the Grayling Subdistrict. The Global Fire Initiative is a TNC program that encompasses both the FLN and LANDFIRE to monitor and restore fire-adapted ecosystems. In addition, its restoration project includes the U.S. Fire Training Program and the U.S. Wildland Fire Education Program, both of which are national collaborative programs to educate agency staff, landowners, and others. TNC should consider extending these programs to the Grayling Subdistrict as part of their overall fire strategy.

Invasive Species Initiative
The Global Invasive Species Initiative is a global response by TNC to the growing problem of invasive species. There are many ongoing projects in the United States, from early detection and response to outreach and education to controlling established invasives. These projects are often collaborative projects between TNC and local agencies and landowners. TNC should work to establish invasive species prevention and control programs in the Grayling Subdistrict to help protect the many rare and endangered species that live there, whether it is distributing information to landowners about how to identify and remove invasives or assisting public agencies in preventing, detecting, and removing invasive species.

Partnerships
In addition to TNC programs, there are many conservation and education groups and events in Michigan that may serve as partners in educating children and adults about the special communities and species in the Grayling Subdistrict. Some of these potential partners are listed below, in alphabetical order. Following a description of the partner organizations, a contact person(s) is listed.

Annual Kirtland's Warbler Festival
The annual Kirtland's warbler festival is held at Kirtland Community College in Roscommon, MI. It includes a workshop day where scientists, experts, and others can present research, area natural history, or even entertainment, and other days include birdwatching, kids' activities, arts and crafts, and field trips. There is also an area for displays by agencies and conservation groups. TNC could participate by helping to organize volunteers or a presentation on conservation.

Jim Enger, Marketing Director
Kirtland Community College
10775 N. St. Helen Rd.
Roscommon, MI 48653
Phone: (989) 275-5000 ext. 266
E-mail: engerj@kirtland.edu
Web: http://warbler.kirtland.edu/Default.htm

Au Sable Institute of Environmental Studies
The Au Sable Institute is located in Mancelona, MI, in Kalkaska County, near our project area. The Institute provides environmental education for K-12 students and retreats and lectures for adults. The lectures include scientific experts and information on the ecosystems of northern Lower Michigan. TNC could get involved here by working with them to increase teaching to both adults and children about the importance of fire and involvement in conservation.

Administration Office
Au Sable Institute
3770 Lake Drive SE
Grand Rapids, MI 49546
Phone: (616) 526-9952
Fax: (616) 526-9955
E-mail: administration@ausable.org
Web: www.ausable.org

Kalkaska Conservation District
Kalkaska County lies on the eastern side of the Grayling Subdistrict, and its conservation district is the most active of those in the subdistrict. With monthly meetings and other events and information, this group is a prime example of a local partner for TNC to work with to organize field trips and seminars and disseminate information about conservation in the Grayling Subdistrict. TNC could work with the Kalkaska Conservation District to help local landowners obtain information on appropriate land management and species conservation in the Grayling Subdistrict.

Russ LaRowe, District Manager
605 N. Birch St.
Kalkaska, Michigan 49646
Phone: (231) 258-3307
Fax: (231) 258-3318
E-mail: rlarowe@kscd.org
Web: www.kscd.org

Other conservation districts to partner with include the Crawford-Roscommon Conservation District, the Oscoda Conservation District, the Ogemaw Conservation District, and the Otsego Conservation District.

The Michigan Audubon Society

Michigan's oldest conservation society, the Michigan Audubon Society is part of the larger National Audubon Society. The society works to promote education and conservation of birds and their habitat. An initiative of the Audubon Society that TNC could participate in is the Important Bird Areas (IBA) initiative. The Audubon Society works to identify areas that are important for migrating and rare birds to designate them as IBAs. Once designated, protection activities include forming preserves, maintaining and restoring habitat, and educating people on the importance of conservation. Now is the ideal time to get involved: the IBA program in Michigan is just getting started.

Peggy Ridgway, President
Michigan Audubon Society
6011 West St. Joseph Hwy
Lansing, MI 48750
Phone: (517) 886-9144
Fax: (517) 886-9466
E-mail: rbirdlady@voyager.net
Web: www.michiganaudubon.org/

Important Bird Areas Contact:
Ray Adams
Kalamazoo Nature Center
7000 North Westnedge Avenue
Kalamazoo, Michigan 49009-6309
Phone: (269) 381-1574
E-mail: radams@naturecenter.org

Michigan United Conservation Clubs (MUCC)

As mentioned in chapter 4, MUCC is an umbrella group for Michigan sportspersons. In addition to their conservation work, MUCC coordinates the WISE Project environmental education curriculum for students in grades K–12. In addition, MUCC conducts adult education seminars and Wildlife Encounters™, a program directed at increasing knowledge about Michigan's native wildlife through live presentations to schools, organizations, and other special groups. They also publish a children's wildlife magazine and hold a summer camp for children. Finally, MUCC supports scientific management and has staff dedicated to monitoring and influencing Michigan's natural resource laws. TNC could work with MUCC by providing materials for use in the education curriculum or by designing and facilitating adult seminars on the rare and endangered species in the Grayling Subdistrict or the role of fire in the subdistrict's ecosystems. TNC could also work with MUCC to inform the public about appropriate management and natural resource laws.

Michigan United Conservation Clubs
P.O. Box 30235
Lansing, MI 48909-7735
Phone: (517) 371-1041
Fax: (517) 371-1505
http://www.mucc.org

Project Learning Tree (PLT)
PLT is a group started in 1973 to work with teachers on educating students as part of their scientific curriculum about ways to get involved in improving the environment. Sponsored in Michigan by the Michigan Department of Natural Resources, Binder Park Zoo, and the Michigan Forest Resource Alliance, it provides workshops and educational materials and activities to teachers, agency staff, and other outreach groups to deliver an environmental education curriculum. The Michigan Prescribed Fire Council is currently considering adding information about wildfires in Michigan (specifically in the jack pine system) to the PLT curriculum. The Council will be meeting with the PLT in the future to discuss potential involvement. TNC could get involved by providing materials for use in the PLT curriculum or by facilitating workshops for teachers on fire or the Grayling Subdistrict ecosystems.

Kathy Fischer
Binder Park Zoo
7400 Division Drive
Battle Creek, MI 49014
Phone: (269) 979-1351
Fax: (269) 979-8834
E-mail: kfischer@binderparkzoo.org
Web: www.michiganplt.org

Ada Takacs
Michigan DNR
Forest, Mineral and Fire Management Division
8717 North Roscommon Rd.
Roscommon, MI 48653
Phone: (989) 275-5151 ext 2049
Fax: (989) 275-5167
E-mail: takacsa@michigan.gov
Web: www.michiganplt.org

Project Wild
This program provides curriculum and training for instructors of grades K-12 in how to view the world from an environmental standpoint. It encourages learning about wildlife-based conservation and environmental responsibility. The program provides educator workshops and materials for teaching children in an informal or classroom environment. TNC could use this program as an avenue to disseminate information to children and adults in the Grayling Subdistrict about the special ecosystems and species and conservation needed there.

Project Wild
147A Natural Resources
Michigan State University
East Lansing, MI 48824
Phone: (517) 355-1712
Fax: (517) 432-3597
E-mail: elshoff@msu.edu
Web: www.carrs.msu.edu/projectwild/

The Stewardship Network
The Stewardship Network works with organizations and individuals to increase the capacity for conservation and management in Michigan. It has worked with many partners and volunteers in southern Michigan since 1998 to increase the availability of information and training to protect Michigan's native biodiversity. The Network has established several clusters of organizations that function as networks across smaller areas, organizing workdays and trainings for local groups and individuals. TNC should work with the Stewardship Network to establish a cluster in the Grayling Subdistrict, including local conservation districts, education groups, and interested volunteers.

Lisa Brush
Stewardship Network
1831 Traver Road
Ann Arbor , MI 48105
Phone: (734) 395-4483
E-mail: lbrush@umich.edu

The U.S. Fish and Wildlife Service (USFWS)
The USFWS has myriad programs available for education and land management for wildlife. In addition, it offers funding for conservation and restoration and is eager for partnerships in education and management. TNC could work to form a partnership with the USFWS in the Grayling Subdistrict to encourage landowners to take part in the many available programs and sources of funding. TNC can also work with the USFWS to promote environmental education in the subdistrict.

USFWS Conservation Partnerships
Phil Million
Phone: (703)358-1711
E-mail: Phil_Million@fws.gov
Web: http://www.fws.gov/partnerships/

Objective 5a: Camp Grayling
By 2010, ensure the protection of the high quality wetlands at Camp Grayling including the mesic sand prairie wetland complex (Portage Creek-Howes Lake Complex) with populations of *Solidago houghtonii*.

Strategic action: Designate the high quality natural communities at Camp Grayling as a State Natural Areas or state-designated High Conservation Value Areas.

The Michigan Natural Features Inventory (MNFI) has conducted several surveys of the natural features of the Camp Grayling Military Reservation. MNFI began work at Camp Grayling in the early 1990's. During these initial surveys, MNFI staff identified numerous natural communities, including the Portage Creek-Howes Lake Complex, as areas of high ecological integrity. The Portage Creek-Howes Lake Complex consists of a shrub and grass dominated wetland and mesic sand prairie located along a three-mile band extending from the west side of Howes Lake to the southwest, parallel to Portage Creek. The prairie is fragmented into eighteen patches totaling close to 100 acres, yet it still experiences natural hydrologic fluctuation throughout the year (Higman et al. 1994). The wetland complex harbors several endemic, endangered, and species of special concern identified in this plan such as the only known occurrence of octoploid variety of *Solidago houghtonii*. Higman et al. (1994) also documented Clinton's bulrush *(Scirpus clintonii),* Vasey's rush *(Juncus vaseyi),* New England violet *(Viola novae-angliae),* the secretive locust *(Appalachia arcana)* and the eastern massasauga *(Sistrurus catenatus catenatus)*.

In 2004, the MNFI conducted a reevaluation of 14 natural communities previously evaluated during the initial surveys. Nine of these communities are wetland types targeted in this plan including the mesic sand prairie Portage Creek-Howes Lake Complex, three intermittent wetlands, two northern fens, two bogs, and a poor fen (MNFI 2006a). The unpublished report of this survey effort identifies specific threats such as the spread of invasive species into the Portage Creek-Howes Lake Complex, altered water table levels, and minimal off road vehicle damage. The report includes valuable detailed ecological descriptions and recommendations for protection that should guide future wetland conservation at Camp Grayling. The integrity of these natural communities and species are dependent on the implementation of these recommendations, active management, and monitoring of the systems.

Because Camp Grayling Military Reservation is leased to the State Department of Military Affairs by the Department of Natural Resources, protection of natural areas within the Camp will require coordination with both agencies. The MI DNR has established a hierarchal cataloging system for areas within the State forests that have been identified for their biodiversity values. The categories include Ecological Reference Area, High Conservation Value Area, and Special Conservation Areas with the Ecological Reference Area considered the highest value biodiversity area. Each category also has associated management and protection status. The Nature Conservancy and/or the Grayling working group may have the opportunity to suggest the State consider specific areas such as the Portage Creek-Howes Lake Complex at Camp Grayling as an area of high biodiversity value in the Ecoregional Plan development for the northern Lower Peninsula (objective 2).

Objective 5b: Management
By 2015, decrease the threat level of incompatible land management practices on *Sistrurus catenatus catenatus*.

A major threat to the eastern massasauga is land management practices that are incompatible with the snake's life cycle and habitat needs. TNC will be able to have the most impact on private landowners in the Grayling Subdistrict, where land management practices can be changed more readily with education and funding. Some federal and state habitat restoration programs that can provide funding are listed below, along with the Candidate Conservation Agreement for the snake, which should be supported by TNC.

Strategic actions:

- **Identify and educate private landowners who have populations of *Sistrurus catenatus catenatus* on their property about the Candidate Conservation Agreement with Assurances.**
- **Identify areas where incompatible land management practices are a threat to *Sistrurus catenatus catenatus.***
- **Educate practitioners about the potential effects of prescribed burning on *Sistrurus catenatus catenatus.***

Private Land Conservation Programs

Wildlife Habitat Incentives Program
This program of the USDA Natural Resources Conservation Service provides cost-sharing and instruction for private landowners on environmental quality, wetlands, farmland protection, and wildlife habitat. Two of the programs that apply most to the Grayling Subdistrict are the Wetlands Reserve Program, which aids volunteer landowners in preserving and restoring wetlands on their property, and the Wildlife Habitat Incentives Program, which helps private landowners develop and improve wildlife habitat on their land. Applicants apply to the USDA for grants with an agreement that they will follow the prescribed management practices for 5, 10, or 15 years. For 2005, Michigan was given $217,161 in funding for farm and ranch lands protection and $889,590 for wetlands reserves (Bish 2006). These programs might help private landowners who are interested in restoring their land but who need training and monetary aid. TNC could assist in educating private landowners that these programs exist and by helping them apply and learn about managing their land.

Albert Cerna
Wildlife Habitat Incentives Program Manager
Phone: (202) 720-9358
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Web: http://www.nrcs.usda.gov/programs/whip/

The Landowner Incentive Program (LIP)
The LIP program is a program administered by the MI DNR (with funding from the USFWS and others under the Endangered Species Act) to help local private landowners restore parts of their lands to the original ecosystem types in the area by aiding in funding and training. Like the Wildlife Habitat Incentives Program, it involves a multiple-year contract for managing the

restored ecosystems. In the northern Lower Peninsula, the MI DNR is focusing on restoring jack pine barrens through prescribed fire and other methods. The program has been very successful over the past year in securing funding for prescribed burns and in signing up landowners. The LIP biologist in the area, Brian Piccolo, has already worked with TNC in making a video about prescribed burns. TNC should continue to work with him to expand the program and secure funding for continuing its work. TNC and LIP program administrators can continue to encourage local private landowners to restore jack pine barrens and other rare communities in the Grayling Subdistrict.

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Eastern Massasauga Candidate Conservation Agreement (CCA)
The USFWS and MI DNR are creating a candidate conservation agreement with assurances for the eastern massasauga rattlesnake in Michigan. Landowners who sign on to the agreement can get funding and aid in managing their land as ideal habitat for the snakes over at least five years. TNC should aid in finding and encouraging landowners to join the CCA and to independently follow good land management practices that do not harm the snake, such as disking and mowing. TNC should also help educate people about the snakes and discourage killing and torturing the snakes, perhaps as a partnership with the USFWS and MI DNR.

Objective 6a: Wetlands
By 2010, ensure the protection of isolated wetlands less than 5 acres in size on private and public lands.

Strategic action: Work with the Department of Environmental Quality to pass legislation to ensure that isolated wetlands are incorporated into the current wetlands protection legislation.

The 2001 Supreme Court decision (known as the SWANCC decision) in the case of the United States vs. the Solid Waste Agency of Northern Cook County effectively removed the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers' ability to regulate activities in isolated wetlands under Section 404 of the Clean Water Act (U.S. EPA 2006). This decision left the regulation and protection of isolated wetlands in the hands of the states. In the past five years many states, counties, and local units of government have passed laws and ordinances to fill the regulatory gap left by the SWANCC decision.

In Michigan, the Army Corps of Engineers has designated the Department of Environmental Quality as the agency responsible for implementing federal protection and regulation of non-coastal wetlands (Michigan Department of Environmental Quality 2006). Additionally the State of Michigan has its own wetland regulation legislation, Part 303 Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1999 PA 451, as amended. Since 1984 the Department of Environmental Quality has been simultaneously implementing

the federal and state laws. The State's wetland protection law, Part 303, regulates wetlands that meet the following requirements (Michigan Department of Environmental Quality 2006):

- Connected to one of the Great Lakes or Lake St. Clair
- Located within 1,000 feet of one of the Great Lakes or Lake St. Clair
- Connected to an inland lake, pond, river, or stream
- Located within 500 feet of an inland lake, pond, river, or stream
- Not connected to one of the Great Lakes or Lake St. Clair, or an inland lake, pond, stream, or river, but are more than 5 acres in size and located in counties with a population of more than 100,000
- Not connected to one of the Great Lakes or Lake St. Clair, or an inland lake, pond, stream, or river, and less than 5 acres in size, but the DEQ has determined that these wetlands are essential to the preservation of the state's natural resources and has notified the property owner

Part 303 does not regulate isolated wetlands that are less than five acres in size and not determined by the Department of Environmental Quality to be essential. As a result, Michigan's state wetland law exempts many truly isolated wetlands (National Wildlife Federation 2001). Prior to the SWANCC decision the U.S. EPA and the State of Michigan had identified that this gap in the state law made it less stringent then federal Section 404 law. The two agencies were discussing how to strengthen the state law as a part of the U.S. EPA's periodic review of the Michigan's assumption of regulatory authority of Section 404. Unfortunately, the SWANCC decision eliminated the incentive for the State to strengthen its wetland protection laws to include isolated wetlands. Therefore isolated wetlands are no longer regulated under state or federal law (National Wildlife Federation 2001).

An amendment to Part 303 of the Natural Resources and Environmental Protection Act, 1999 PA 451 to regulate isolated wetlands less than five acres in size would provide broad-based protection for these vulnerable wetlands across the State. As of early 2006, the State legislature is not currently considering any such amendment. A first step towards implementing this action would be to contact Michigan wetland and water resource groups such as the Michigan Wetland Action Coalition to determine if larger support exists to launch an advocacy campaign for stronger state level wetland protection.

Strategic Action: Work with local units of government in the Grayling Subdistrict to develop and enact local wetland ordinances.

Michigan local units of government have the authority to pass wetland ordinances that are more rigorous that the state legislation, including those that regulate isolated wetlands smaller that five acres in size. As of October 2005, 44 communities had adopted wetland ordinances. A majority of these communities are in the more highly development southeastern Michigan counties (Michigan Department of Environmental Quality 2006).

A potential wetland protection strategy would be to work with specific local units of government to encourage the protection of small ecologically significant isolated wetlands through ordinances.

Objective 6b: Roads and Development
Reduce the negative impacts of roads and development on the targets.

While roads provide an inlet for disturbance and invasive species, they also play an important role in the regional economy. They enable tourism and many recreational activities, such as camping, hunting, and fishing (USDA Forest Service 2005b). In addition, they bring money to counties that do not have large populations through land management practices such as timber production. As of 2002, counties received about $1,500 per year for every mile of county road for maintenance (USDA Forest Service 2002). In addition, the USDA Forest Service provides money to counties for upgrades and as part of the 25 Percent Fund, in which 25% of the gross receipts from timber, minerals, and recreation on National Forests are directed towards roads and schools (USDA Forest Service 2002). It is important to take into account the economical value of roads when determining how to manage them, especially as the population is increasing and using the roads more.

The USDA Forest Service Forest-Scale Roads Analysis (2002) includes many recommendations for managing roads in the Huron-Manistee National Forests. Some of these strategies include decommissioning roads that create redundant access to sites or that are unused, reconstructing or maintaining roads to reduce their impact on the environment and to increase their safety level, and continuing to keep roads out of semiprimitive and restricted natural areas. In addition, the USDA Forest Service plans to continue to work with counties to maintain county roads in the forests. At this time, the USDA Forest Service has no plans to add new roads to the forests, but this may change over time.

The Nature Conservancy can get involved by working with the USDA Forest Service, MI DNR, and counties to prevent the construction of new roads whenever possible and to work to reduce the impacts of erosion, pollution, and invasive species on native ecosystems. Specifically, TNC can conduct studies to show how invasive species are propagated along vehicle travel corridors and what effects they have, if any, on the rare and endangered species of the Grayling Subdistrict. They should also use only existing roads for restoration and management activities and participate in outreach encouraging sustainable use and development in the subdistrict. Individual restoration projects could be performed on streams where riparian zones or fish populations are affected by road adjacency or crossings.

Strategic actions:

- **Work with the USDA Forest Service and MI DNR to consolidate their landholdings to help reduce fragmentation by roads.**
- **Encourage the MI DNR to conduct a roads analysis similar to the USDA Forest Service's 2002 Roads Analysis for the Huron-Manistee National Forests to determine if they can decommission or improve any roads in the subdistrict.**
- **Work with biologists to identify areas for seasonal road closure and signage based on wildlife movement.**

Objective 6c: Off-Road Vehicles (ORVs)
Work with the MI DNR to reduce the impact of illegal ORV use on public lands.

Illegal ORV use poses a threat to several Grayling target communities and species. Illegal uses include "illegal scramble areas and hill climbs and riding in wetlands or river/lake shorelines" (Nelson 2005). Off-trail ORV use can lead to soil compaction and erosion, destruction of sensitive plant populations, introduction of invasive species, and undue stress to wildlife populations (Penskar 1997). An assessment of Michigan ORV trails conducted by the MI DNR noted illegal ORV uses on 44 (54%) of the trails/routes assessed.

Strategic action: Help disseminate information about the MI DNR ORV Trail Maintenance and Restoration grants to appropriate groups for restoration of target ecosystems.

Michigan's ORV Trail Improvement Fund was established by Public Act 17 in 1991 and is funded completely by annual ORV license fees (Nelson 2005a). The majority of the fund must be distributed as follows (Nelson 2005b):

- 50% for trail maintenance and development
- 12.5% for environmental damage restoration on public lands
- 31.25% for law enforcement

Funding for trail maintenance and environmental damage restoration is distributed as grants to public agencies and nonprofit organizations (Nelson 2005b). From 2002-2005, total dollars spent through grants hovered around $900,000 for maintenance and between $184,000 and $250,000 for restoration. 15 to 17 organizations received grants for trail maintenance while 3 or 4 received grants for environmental restoration. Nelson (2005b) notes that "very few organizations are involved in ORV damage restoration." Nelson also reports that only 45% of the ORV Trail Improvement Fund is being spent on both trail maintenance and environmental restoration, which is much lower than the 62.5% total called for by law. There was also a $4,027,400 balance in the ORV Trail Improvement Fund in September 2004 (Nelson 2005b).

These factors indicate that more funding exists for ORV trail maintenance and damage restoration activities on public lands than is being utilized. TNC can take advantage of this opportunity by applying for grants or by notifying other restoration groups.

Strategic action: Work with the MI DNR and partner organizations to incorporate education about the impacts of ORVs on ecosystems into existing safety education programs.

The MI DNR is responsible for implementing an ORV information, safety education, and training program for the public, particularly youth. The MI DNR does this in partnership with a variety of organizations such as nonprofit organizations, local governments, and other state departments. This safety education program could be a good opportunity for TNC to disseminate information on the ecological impacts of improper ORV use to riders.

Strategic action: Provide information on the impacts of ORVs on our target ecosystems to all ORV licensees.

All ORV users in Michigan are required by law to purchase an annual license, so this could serve as another public education opportunity. A leaflet or brochure about the ecological impacts of improper ORV use (emphasizing the impacts on the plan's targets) could be distributed when users receive their annual license.

Part III: Methods, Results, and Discussion

Chapter 10: Discussion

Discussion

The Grayling Subdistrict Conservation Plan provides a framework for The Nature Conservancy (TNC) to begin to protect the many rare and endangered species and communities in the Grayling Subdistrict. By combining the ecosystem approach with TNC's Five-S and Conservation Action Planning processes, we were able to lay out specific targets for conservation and priorities threats and strategic actions aimed at abating the threats. Using literature resources, GIS data, and interviews with agency and private experts, we were able to assemble accurate information on many species and communities that we could then enter into a workbook tailored to TNC's needs. Using the threats and sources of stress in combination with our knowledge of the land ownership and management in the area, we compiled a list of objectives for TNC to implement, ranging from forming a collaborative working group with agencies to education to influencing future agency actions.

We are confident that our project gives TNC a base to begin working with the many stakeholders in the Grayling Subdistrict region. A collaborative effort is both appealing and necessary in a region with multiple landowners and many management issues. TNC is the ideal organization to carry out such an effort—its long history of conservation planning and dedication to preserving biodiversity, along with working relationships with many of the stakeholders already in place give it the skills and staff necessary to implement the plan.

Limitations

This project is not to serve as a comprehensive or conclusive resource on the ecosystems and species of the Grayling Subdistrict. It has covered only a small portion of the ecosystems, community types, species, and related conservation issues in the subdistrict. As discussed in chapter 6, we had to limit the number and types of targets chosen and therefore omitted many important species, community types, and ecosystems. This project was designed to be a relatively general overview of the ecology of and threats to selected conservation targets. Due to time and personnel constraints we were unable to collect original data in the field and had to rely on literature and interviews with experts for all of our information gathering. Additionally we had only one year to complete our research and writing. The GIS analysis was rudimentary and meant to serve as a starting point for more thorough and professional analysis.

Opportunities for Further Research

This project represents a broad-scale conservation plan for the terrestrial targets in the Grayling Subdistrict. Although we think the plan represents a thorough review and consideration of the targets, threats, sources of threats, and conservation strategies for the Grayling Subdistrict, we realize that there are numerous opportunities to strengthen the conservation plan. Detailed below are several specific opportunities for future research and means to augment the existing plan.

Aquatic Targets

Due to a limited time frame and lack of aquatic expertise within the project team, we chose to focus on the terrestrial targets within the Subdistrict. Consequently, there are aquatic targets deserving consideration that may potentially be included in a more comprehensive plan for the Grayling Subdistrict. In our plan, we limited the conservation targets by nesting species, when appropriate, within their associated community types. Because it is structured this way,

the TNC can easily include aquatic targets as an addition to the existing plan in the future. We suggest that TNC consider the following potential aquatic targets in conducting this portion of the planning process:

- Manistee and AuSable River headwater streams
- Headwater lakes
- Channel darter *(Percina copelandi) (G4/S1S2)*
- Deepwater pondsnail *(Stagnicola contracta) (G1/S1)*
- Elktoe *(Alasmidonta marginata) (G4/S2S3)*
- Hill's pondweed *(Potamogeton hillii) (G3/S2)*
- Rainbow *(Villosa iris) (G5/S2S3)*
- River redhorse *(Moxostoma carinatum) (G4/S1)*
- River darter *(Percina shumardi) (G5/S1)*
- Round pigtoe *(Pleurobema coccineum) (G4/S2S3)*
- Slippershell Mussel *(Alasmidonta viridis) (G4G5/S2S3)*
- Spotted Turtle *(Clemmys guttata) (G5/S2)*

Wide-Ranging and Moderately Threatened Targets

In addition, there are numerous threatened community types and species that can be found in the Grayling Subdistrict, but these potential targets are not immediately threatened or endemic to the Subdistrict. We chose not to consider these as targets; however, TNC may wish to further investigate specific high-quality examples of these communities or species occurrences that occur in the subdistrict and therefore warrant conservation attention. A subset of examples is included below:

- Dry northern forest *(G3/S3)*
- Old growth red and white pine
- Rich conifer swamp *(G4/S3)*
- Boreal brachionycha *(Brachionycha borealis) (G4/S1S2)*
- Canadian milk vetch *(Astragalus canadensis) (G5/S1S2)*
- Calypso orchid *(Calypso bulbosa) (G5/S2)*
- Eastern box turtle *(Terrapene carolina carolina) (G5/S2S3)*
- False violet *(Dalibarda repens) (G5/S1S2)*
- Fir clubmoss *(Huperzia selago) (G5/S3)*
- Fleshy stichwort *(Stellaria crassifolia) (G5/S1S2)*
- Fragile prickly pear *(Opuntia fragilis) (G4G5/S1)*
- Ginseng *(Panax quinquefolius) (G3G4/S2S3)*
- Least Bittern *(Ixobrychus exilis) (G5/S2)*
- King Rail (*Rallus elegans) (G4/S1)*
- New England violet *(Viola novae-angliae) (G4/S2)*
- Pine drops *(Pterospora andromedea) (G5/S2)*
- Pussy toes *(Antennaria parvifolia) (G5/S1)*
- Yellow rail *(Coturnicops noveboracensis) (G4/S1S2)*
- Whorled pogonia *(Isotria verticillata) (G5/S2)*

Site-Specific Conservation

Aside from a few specific locations suggested by regional experts, such as the mesic sand prairie at Camp Grayling, we did not scale our analysis and strategies down to a site level. The identification of sites with high conservation potential in the Subdistrict is a way to further enhance and focus the conservation plan. The change-level GIS analysis (see chapter 7) conducted as a component of this plan represents a filter that TNC can use to identify relatively unchanged jack pine barrens, dry sand prairies, and nonforested wetlands that may be areas for site-based conservation projects.

Should TNC decide to become involved in site-based conservation projects, land protection, or acquisition in the subdistrict, it may require county or township level parcel identification, additional GIS analysis, and ground truthing. The patchwork landscape and high rate of second home ownership in the Grayling Subdistrict lends itself to targeted conservation of private inholdings within public lands through the use of conservation easements, fee acquisition, or a conservation buyer program.

Measures of Success

In consultation with staff from The Nature Conservancy, our project team decided not to draft specific measures of success for the conservation plan at this time. Because the measures of success component of the Five-S conservation planning process serves as an internal auditing system, The Nature Conservancy of Michigan should complete this step once they have refined their level of commitment in the Grayling Subdistrict.

Appendix A: NatureServe Global and State Element Ranking Criteria

NatureServe and the Michigan Natural Features Inventory conduct regular status assessments or evaluations of the relative imperilment of species and natural communities. Based on these assessments and the opinion of independent experts, NatureServe (2006a) and MNFI (2003) assign each species and natural community a conservation status rank. Specific definitions for global and state conservation status ranks are provided below:

Rank	Definition
G1	**Critically imperiled**: at very high risk of extinction on a global scale due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
G2	**Imperiled**: at high risk of extinction on a global scale due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
G3	**Vulnerable**: at moderate risk of extinction on a global scale due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
G4	**Apparently secure**: uncommon but not rare on a global scale; some cause for long-term concern due to declines or other factors.
G5	**Secure**: common; widespread and abundant on a global scale.
S1	**Critically imperiled**: in the state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation in the state.
S2	**Imperiled**: in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state.
S3	**Rare or uncommon**: in state (on the order of 21 to 100 occurrences).
S4	**Apparently secure**: in state, with many occurrences.
S5	**Demonstrably secure**: in state and essentially ineradicable under present conditions.
Rank/Rank (S3/S4)	**Intermediate rank**: for example a species or natural community with a S3/S4 rank has been assessed as in-between rare or uncommon and apparently secure.

Appendix B: The Conservation Action Planning Workbook

Target Viability Summary Table

Conservation Target	Category	Key Attribute	Indicator	Current Indicator Status	Current Rating	Desired Rating
Jack pine barrens	Landscape Context	Fire regime - (timing, frequency, intensity, extent)	Fire interval	The natural fire interval is altered by an order of magnitude (Mike Kost). Historically, fires occurred at high frequency and low intensity, but now any fires that occur are high intensity and low frequency. (Paul Thompson)	Poor	Good
Jack pine barrens	Landscape Context	Fire regime - (timing, frequency, intensity, extent)	Fire size	Due to fire suppression and ecosystem fragmentation, the sizes of fires in the Grayling Subdistrict are greatly reduced compared to natural landscape-scale fires. (Paul Thompson)	Poor	Fair
Jack pine barrens	Landscape Context	Landtype Association	Flat to gently rolling topography (capable of carrying wildfires) or frost pockets (ice contact)	It is good because most of the barrens that exist are on these types of topography.	Good	Very Good
Jack pine barrens	Landscape Context	Landtype Association	Sandy, acidic, well- to excessively well-drained	The well-drained sandy soils are available for barrens to be restored.	Good	Very Good

Conservation Target	Category	Key Attribute	Indicator	Current Indicator Status	Current Rating	Desired Rating
Jack pine barrens	Landscape Context	Spatial occurrence pattern and structure of open (barrens), intermed-iate, and mature jack pine forest	Minimum dynamic area	Although disturbances occurred at large scales historically, the barrens complexes that exist today in the range of tens to hundreds of acres (Huber, Piccolo interviews) still provide for patterns of successional stages reflective of historical patterns	Fair	Good
Jack pine barrens	Condition	Invasive species	Presence of invasive species	The interior of currently existing jack pine barrens is good but invasive species are in existence on roadsides and disturbed areas.	Good	Very Good
Jack pine barrens	Condition	Native increasers	Relative abundance of native increasers	A number of current barrens sites are dominated by these native increasers	Fair	Very Good
Jack pine barrens	Condition	Species composi-tion	Presence of jack pine barrens indicator species	Most of the existing jack pine barrens are composed of the listed species.	Good	Very Good
Jack pine barrens	Size	Size / extent of character-istic jack pine barrens	Percentage of historical acreage	Current pine barrens amount to less than one percent of the historical acreage.	Poor	Fair
Dry sand prairie	Landscape Context	Fire regime - (timing, frequency, intensity, extent)	Fire interval	The natural fire interval is altered by an order of magnitude (Mike Kost).	Poor	Good

Conservation Target	Category	Key Attribute	Indicator	Current Indicator Status	Current Rating	Desired Rating
Dry sand prairie	Landscape Context	Landtype Association	Outwash plain with level topography and frequent growing season frosts	It is good because there is potential for restoration on the LTA.	Good	Very Good
Dry sand prairie	Landscape Context	Landtype Association	Sandy, acidic, well- to excessively well-drained	Many prairie soils have been eroded or turned into pine plantations, which might alter its restoration potential.	Fair	Good
Dry sand prairie	Landscape Context	Spatial occurrence pattern of dry sand prairie	associated with pine barrens, oak-pine barrens, and oak barrens.	Dry sand prairies are not currently found in association with these ecosystems	Poor	Good
Dry sand prairie	Condition	Invasive species	Presence of invasive species	Best guess.	Fair	Good
Dry sand prairie	Condition	Species composition	Presence of dry sand prairie indicator species	In our limited search, we haven't uncovered any examples of high quality prairies in the Grayling Subdistrict.	Poor	Good
Dry sand prairie	Size	Size/ extent of characteris-tic dry sand prairies	Percentage of historical acreage	Current dry sand prairies amount to less than one percent of the historical acreage (approximately 6,000 acres in the Grayling Subdistrict).	Poor	Fair

Conservation Target	Category	Key Attribute	Indicator	Current Indicator Status	Current Rating	Desired Rating
Wetlands	Landscape Context	Fire regime - (timing, frequency, intensity, extent)	Fire interval	Based on our general knowledge of altered fire regimes in the Grayling Subdistrict, we are estimating that the fire interval is much longer than what is natural. The Forest Service does not conduct any prescribed burns on wetlands (Paul Thompson).	Poor	Good
Wetlands	Landscape Context	Hydrologic regime - (timing, duration, frequency, extent)	Hydrologic regime as compared to reference condition for specific wetland type	Over 50% of the original wetlands in Michigan (ca. 1780) have been lost. (Mitsch and Gosselink 2000) However, what is left on public land is mostly being protected.	Fair	Good
Wetlands	Landscape Context	Landtype Association	Poorly drained depressions on outwash, sandy lake plain, and ice contact terrain	As far as we can determine, the remaining wetlands in the Grayling Subdistrict exist on these landforms.	Good	Good
Wetlands	Condition	Invasive species	Presence of invasive species		Fair	Good
Wetlands	Condition	Species of conserva-tion concern	Presence of species of conservation concern	Based on the state rank of S1/S2/S3 and the MNFI Biotics database.	Poor	Good
Wetlands	Size	Size/ extent of characteris-tic wetlands	Percentage of current acreage protected	Most wetlands on public lands in the Grayling Subdistrict are protected by state and national agencies. We do not know about private lands.	Good	Very Good

Conservation Target	Category	Key Attribute	Indicator	Current Indicator Status	Current Rating	Desired Rating
Rare turtles of concern	Condition	Population structure and recruitment for Emys blandingii	Age distribution	There is little evidence of juvenile turtles surviving to reproductive age. Age distribution is skewed towards older turtles; it is basically a ghost population.	Poor	Good
Rare turtles of concern	Condition	Population structure and recruitment for Glyptemys insculpta	Age distribution	There is little evidence of juvenile turtles surviving to reproductive age. Age distribution is skewed towards older turtles; it is basically a ghost population.	Poor	Good
Rare turtles of concern	Size	Abundance of Emys blandingii	Number of occurrences	We know the population will decrease as older turtles die out because of the skewed population structure.	Poor	Good
Rare turtles of concern	Size	Abundance of Glyptemys insculpta	Number of occurrences	We know the population will decrease as older turtles die out because of the skewed population structure.	Poor	Good
Sistrurus catenatus catenatus	Landscape Context	Connectivity among occurrences	Distance between conservation areas	In order to be conservative, we are assigning this a fair ranking because there is limited information on how close populations need to be in order to interact.	Fair	Good

Conservation Target	Category	Key Attribute	Indicator	Current Indicator Status	Current Rating	Desired Rating
Sistrurus catenatus catenatus	Condition	Habitat extent	Number of acres of habitat	Within the Grayling Subdistrict, wetlands are interspersed with upland habitat due to the highly varied physiography. However, about 50% of Michigan's wetlands have been lost (Mitsch and Gosselink 2000).	Fair	Very Good
Sistrurus catenatus catenatus	Condition	Habitat quality	Mosaic habitat	Within the Grayling Subdistrict, wetlands are interspersed with upland habitat due to the highly varied physiography. However, there is not enough open upland adjacent to the wetlands, which is necessary for the snakes (Paul Thompson).	Fair	Very Good
Sistrurus catenatus catenatus	Condition	Population structure & recruitment	Age distribution	Although there is no direct information about age distribution in a population of massasaugas, they are vulnerable to premature death due to poaching and road mortality. Loss of certain segments of the population, especially pregnant females, can have an	Fair	Good

Conservation Target	Category	Key Attribute	Indicator	Current Indicator Status	Current Rating	Desired Rating
Sistrurus catenatus catenatus	Size	Population size	Number of occurrences	Due to the incomplete survey information of massasauga populations in the Grayling Subdistrict, a conservative estimate of the number of occurrences would be a fair ranking.	Fair	Very Good
Appalachia arcana	Size	Abundance of Appalachia arcana	Number of occurrences	MNFI database shows 39 occurrences as of September 2005. We are unsure if this reflects the current distribution and how it compares to historical distributions.	Fair	Good

Viability Comments Table

Conservation Target, Category, Key Attribute, Indicator	Key attribute and indicator comment	Current rating comment	Desired rating comment
Jack pine barrens, Landscape Context, Fire regime (timing, frequency, intensity, extent), Fire interval	Fire is the primary mode of disturbance in jack pine ecosystems.	Conversations with Mike Kost and agency personnel. MNFI pine barrens abstract, Rapid Assessment Reference Condition Model.	We chose a “good” rating as the desired rating as fire is the key component in creating and maintaining jack pine barrens. We did not choose “very good” because barriers such as fear of fire, habitat fragmentation, and wildland-urban interface (Forest Service) exist. The historical fire interval consisted of frequent surface fires at least every 10 years and stand replacement fires on average of 41 years based on the Rapid Assessment Reference Condition Model v2.0.
Jack pine barrens, Landscape Context, Fire regime (timing, frequency, intensity, extent), Fire size	Fire is the primary mode of disturbance in jack pine ecosystems.	Conversations with Mike Kost and agency personnel. MNFI pine barrens abstract, Rapid Assessment Reference Condition Model.	We chose a “fair” rating as the desired rating as fire is the key component in creating and maintaining jack pine barrens. We did not choose “good” or “very good” because barriers such as fear of fire, habitat fragmentation, and wildland-urban interface (Forest Service) exist. The historical fire size based on the Rapid Assessment Reference Condition Model v2.0 ranged from several hundred to several thousand acres.

Conservation Target, Category, Key Attribute, Indicator	Key attribute and indicator comment	Current rating comment	Desired rating comment
Jack pine barrens, Landscape Context, Landtype Association, Flat to gently rolling topography (capable of carrying wildfires) or frost pockets (ice contact)	The topography is important because the flat to gently rolling topography is capable of carrying large wildfires and the frost pockets exert climatic control over species.	Most of the topography and the ideal LTAs are available for occurrences of barrens, although many are currently managed for other purposes.	Many of the barrens in the next 20-50 years will be created barrens, so it is important to make sure they are sited in appropriate LTAs.
Jack pine barrens, Landscape Context, Landtype Association, Sandy, acidic, well- to excessively well-drained	Soil type is an important component in determining which species can occur and in creating drought conditions that increase fire occurrence.	Most of the topography and the ideal soils are available for occurrences of barrens, although many are currently managed for other purposes.	Many of the barrens in the next 20-50 years will be created barrens, so it is important to make sure they are sited in appropriate LTAs.

Conservation Target, Category, Key Attribute, Indicator	Key attribute and indicator comment	Current rating comment	Desired rating comment
Jack pine barrens, Landscape Context, Spatial occurrence pattern and structure of open (barrens), intermediate, and mature jack pine forest, Minimum dynamic area	Conservation efforts in the Grayling Subdistrict need to cover the continuum of shifting barrens and jack pine forests as a dynamic ecosystem. They are all aspects of jack pine- open-mid- dense, young-mid- mature and shift around the landscape with disturbance. See TNC definition for MDA: area needed to ensure survival or reestablishment of target after natural disturbance. (Five-S handbook) -The Forest Service is also using a similar rationale in their 2005 Forest Plan Revision by providing for percentages of barrens in a larger block of land rather than exact locations and measurements. (Alix Cleveland- interview)	Best estimate based on conversations with Phil Huber, Brian Piccolo, and Doug Pearsall.	Reaching a very good rating would be 2,000-10,000 acres based on the Reference Condition Model Tracker Database v.2.0 (part of Landfire, which is a joint program of the Forest Service and TNC). However, this rating would be extremely difficult to reach given the political resistance to opening up the current forested landscape that is designated for timber sales (Huber), Kirtland's warbler management (Thompson), and landowner resistance and lack of education (Piccolo).
Jack pine barrens, Condition, Invasive species, Presence of invasive species	The presence of invasive species such as Poa compressa, Bromus inermis, Hypericum spp., Centaurea maculosa, Hieracium aurantiacum, Elaeagnus umbellata, Molothrus ater, Rumex acetosella, and Didelphis virginiana are threats to the quality of jack pine barrens.	Interviews with Phil Huber, Brian Piccolo, Greg Schmidt, Alix Cleveland, and Paul Thompson.	We think a very good ranking would be no more than 5-10% cover of invasives in barrens. We realize that there is a regional presence of many of these invasives, so zero percent would be infeasible. We feel that as long as invasives are maintained at current levels or reduced, the condition of barrens will not be compromised.

Conservation Target, Category, Key Attribute, Indicator	**Key attribute and indicator comment**	**Current rating comment**	**Desired rating comment**
Jack pine barrens, Condition, Native increasers, Relative abundance of native increasers	The following native increasers have a tendency to form monocultures, outcompeting other native barrens species: Comptonia peregrina Pteridium aquilinum Carex pensylvanica A monoculture does not represent a high-quality barrens.	From our conversations with Phil Huber, Brian Piccolo, Alix Cleveland, Paul Thompson, and Greg Schmidt, we have learned that this is a problem, but we do not know how widespread the problem is.	A high-quality barrens ranking very good should contain a diverse species assemblage including rare and endemic plants of jack pine barrens.

Conservation Target, Category, Key Attribute, Indicator	**Key attribute and indicator comment**	**Current rating comment**	**Desired rating comment**
Jack pine barrens, Condition, Species composition, Presence of jack pine barrens indicator species	A high-quality jack pine barrens would be composed of a majority of the following species, with an “infrequency of trees” (Forest Service definition): Major dominants: - Pinus banksiana Often found: - Pinus resinosa - Pinus strobus - Quercus ellipsoidalis - Prunus serotina Shrubs: - Vaccinium angustifolia - Comptonia peregrina - Corylus americana - Prunus pumila - Salix pumila - Arctostaphylos uva-ursi Herbaceous species: - Schizachyrium scoparium - Danthonia spicata - Carex pensylvanica - Andropogon gerardii - Deschampsia flexuosa - Viola pedata - Aster oolentangiensis - Liatris aspera - Koeleria macrantha - Potentilla arguta - Stipa spartea Rare plants: - Cirsium hillii - Agoseris glauca - Festuca scabrella - Prunus alleghaniensis	MNFI pine barrens abstract Curtis (1959) Vegetation of Wisconsin Interviews with Brian Piccolo, Phil Huber, Alix Cleveland, Mike Kost, Greg Schmidt.	A high-quality barrens ranking very good should contain a diverse species assemblage including rare and endemic plants of jack pine barrens.

Conservation Target, Category, Key Attribute, Indicator	Key attribute and indicator comment	Current rating comment	Desired rating comment
Jack pine barrens, Size, Size/extent of characteristic jack pine barrens, Percentage of historical acreage	Percentage of historical acreage is a commonly used method to evaluate the current and potential size of an ecosystem.	MNFI Pine barrens abstract and interviews with Phil Huber, Brian Piccolo, Mike Kost, Alix Cleveland, and Greg Schmidt.	A fair ranking would be 12,000 acres of high-quality pine barrens, or 10 percent of the 1800s distribution (120,000) of jack pine barrens (Comer et al. 1995). We think this is an achievable goal that would represent a drastic improvement over the current situation. A good ranking for this indicator would be 25% of historical acreage or 30,000 acres of jack pine barrens in the Grayling Subdistrict by 2040.
Dry sand prairie, Landscape Context, Fire regime (timing, frequency, intensity, extent), Fire interval	Fire is the primary mode of disturbance in dry sand prairie ecosystems.	MNFI dry sand prairie abstract and conversations with Mike Kost and Paul Thompson.	Based on our research, fire is the key component in creating and maintaining dry sand prairie. We did not choose “very good” because barriers such as attitudes, habitat fragmentation, and wildland-urban interface (Forest Service) exist. The historical fire interval was more frequent than pine barrens, with a surface fire in the range of 1-10 years.
Dry sand prairie, Landscape Context, Landtype Association, Outwash plain with level topography and frequent growing season frosts	The topography is important because the flat topography is capable of carrying large wildfires and the growing season frosts inhibit the growth of trees.	Most of the topography and the ideal LTAs are available for occurrences of prairies, although many are currently managed for other purposes. MNFI abstract for dry sand prairies and USFS Biological Evaluation for the Huron-Manistee Forest Plan Revision (2005).	Many of the prairies in the next 20-50 years will be created prairies, so it is important to make sure they are sited in appropriate LTAs.

Conservation Target, Category, Key Attribute, Indicator	Key attribute and indicator comment	Current rating comment	Desired rating comment
Dry sand prairie, Landscape Context, Landtype Association, Sandy, acidic, well- to excessively well-drained	Soil type is an important component in determining which species can occur and in creating drought conditions that increase fire occurrence. The Forest Service defines a prairie as occurring on Spartan soil. They may have also occurred on other soil types in association with frequently burned barrens. (Paul Thompson)	USFS Forest Plan Revision Biological Evaluation for the Huron-Manistee National Forest.	Many of the prairies in the next 20-50 years will be created prairies, so it is important to make sure they are sited in appropriate LTAs.
Dry sand prairie, Landscape Context, Spatial occurrence pattern of dry sand prairie, associated with pine barrens, oak-pine barrens, and oak barrens.	The nature of dry sand prairies within the Grayling Subdistrict was smaller, patchy fragments within pine barrens, oak-pine barrens, and oak barrens.	Best estimate based on conversations with Phil Huber, Brian Piccolo, and Doug Pearsall.	Reaching a good rating would mimic the natural distribution of dry sand prairies in small patches nested within the barrens systems. A very good rating would be extremely difficult to reach given the political resistance to opening up the current forested landscape that is designated for timber sales (Huber) and landowner resistance and lack of education (Piccolo).
Dry sand prairie, Condition, Invasive species, Presence of invasive species	The presence of invasive species such as Poa compressa, Bromus inermis, Hypericum spp., Centaurea maculosa, Hieracium aurantiacum, Elaeagnus umbellata, Rosa multiflora, and Rumex acetosella are threats to the quality of dry sand prairie.	MNFI dry sand prairie abstract; Alix Cleveland.	We think a very good ranking would be no more than 5-10% cover of invasives in dry sand prairies. We realize that there is a regional presence of many of these invasives, so zero percent cover would be infeasible. We feel that as long as they are maintained at current levels or reduced, the condition of prairies will not be further compromised.

Conservation Target, Category, Key Attribute, Indicator	**Key attribute and indicator comment**	**Current rating comment**	**Desired rating comment**
Dry sand prairie, Condition, Species composition, Presence of dry sand prairie indicator species	Dry sand prairie is dominated by grasses with less than one mature tree per acre. A dry sand prairie is composed of a majority of the following species: Dominants: - Andropogon gerardii - Schizachyrium scoparium - Carex pensylvanica Other common species: - Danthonia spicata - Deschampsia flexuosa - Koeleria macrantha - Oryzopsis asperifolia - Oryzopsis pungens - Liatris aspera - Campanula rotundifolia - Arctostaphylos uva-ursi - Prunus pensylvanica - Comptonia peregrina - Rubus flagellaris - Vaccinium angustifolium - Pinus banksiana - Pinus resinosa - Quercus ellipsoidalis Rare species: - Cirsium hillii - Festuca scabrella - Agoseris glauca	best guess, MNFI database, and conversation with Mike Kost	A high-quality prairie ranking very good should contain a diverse species assemblage including rare and endemic plants of dry sand prairie.

Conservation Target, Category, Key Attribute, Indicator	Key attribute and indicator comment	Current rating comment	Desired rating comment
Dry sand prairie, Size, Size/extent of characteristic dry sand prairies, Percentage of historical acreage	Percentage of historical acreage is a commonly used method to evaluate the current and potential size of an ecosystem.	MNFI dry sand prairie abstract.	A fair ranking would be 600 acres of good quality dry sand prairie, or 10 percent of the 1800s distribution (6,000 acres) of dry sand prairies (Comer et al. 1995). We think this is an achievable goal that would represent a drastic improvement over the current situation, which is about 125 acres according to the MNFI database. A good ranking for the size indicator for dry sand prairies would be 25% of historical acreage, or 1500 acres by 2040.
Wetlands, Landscape Context, Fire regime (timing, frequency, intensity, extent), Fire interval	Fire plays an important role in maintaining the open condition of many wetlands systems. Without fire, wetlands will be encroached by woody vegetation at an increased rate.	Forest Service Huron-Manistee 2005 Forest Plan Revision Biological Evaluation MNFI abstracts and Natural Communities Draft List and Descriptions	Based on our research, fire is a key component in creating and maintaining openness in wetlands in the Grayling Subdistrict. We did not choose “very good” because barriers such as attitudes, habitat fragmentation, and wildland-urban interface (Forest Service) exist. The historical fire regime would have been similar to that of jack pine barrens because fires moved into wetlands from uplands (Paul Thompson).
Wetlands, Landscape Context, Hydrologic regime (timing, duration, frequency, extent), Hydrologic regime as compared to reference condition for specific wetland type	Hydrologic regime is the most important distinguishing feature of wetlands. (Mitsch and Gosselink 2000)	Mitsch and Gosselink 2000, National Wetland Inventory Conversations with Phil Huber and Mike Kost	A very good rating would be representative of unaltered hydrologic regime, which is impractical given the current land usage. Therefore, we think a good rating would be restoring hydrology to relatively unaltered wetlands and protecting the hydrologic regime in naturally functioning wetlands.

Conservation Target, Category, Key Attribute, Indicator	**Key attribute and indicator comment**	**Current rating comment**	**Desired rating comment**
Wetlands, Landscape Context, Landtype Association, Poorly drained depressions on outwash, sandy lake plain, and ice contact terrain	The landform determines the hydrology, which in turn determines the presence of wetlands.	MNFI occurrences database, LTA book, Natural Communities Draft List and Descriptions.	Any wetland restoration or creation in the Grayling Subdistrict should take into account the physiographic setting.
Wetlands, Condition, Invasive species, Presence of invasive species	The presence of invasive species are threats to the quality of wetlands. Some common species include Phragmites australis, Eurasian water milfoil (Myriophyllum spp.) purple loosestrife (Lythrum salicaria), and reed-canary grass (Phalaris arundinacea).	Best guess. According to Paul Thompson, invasives are increasingly becoming a problem in wetlands.	We think a very good ranking would be no more than 5-10% cover of invasives in wetlands. We realize that there is a regional presence of many of these invasives, so zero percent would be infeasible. We feel that as long as they are maintained at current levels or reduced, the condition of wetlands will not be compromised.

Conservation Target, Category, Key Attribute, Indicator	**Key attribute and indicator comment**	**Current rating comment**	**Desired rating comment**
Wetlands, Condition, Species of conservation concern, Presence of species of conservation concern	The following species of conservation concern were chosen based on their MNFI and NatureServe state rankings (S3, S2, or S1) and can be found in the focal target wetlands of the Grayling Subdistrict: Plants - Eleocharis engelmanii - Juncus militaris - Solidago houghtonii - Oryzopsis canadensis - Lechea pulchella - Lycopodiella appressa - Juncus vaseyi Animals - Appalachia arcana - Planogyra asteriscus - Williamsonia fletcheri - Merolonche dolli	Forest Service Huron-Manistee Forest Plan Revision Biological Evaluation MNFI Biotics Database	A good rating would represent more secure populations of these species.
Wetlands, Size, Size/extent of characteristic wetlands, Percentage of current acreage protected	Because we don't know the historical extent of wetland acreage, we think that the percentage protected of the existing wetlands is a feasible way to measure wetland size and extent.	Conversations with Phil Huber, Mike Penskar, and Mike Kost	Protection of all current wetlands on public and private land would rate very good. Although we know that the current size and extent of wetlands is a decrease from presettlement wetlands, we think that protection of all current wetlands would be a very good goal given current land usage.

Conservation Target, Category, Key Attribute, Indicator	Key attribute and indicator comment	Current rating comment	Desired rating comment
Rare turtles of concern, Condition, Population structure and recruitment for Emys blandingii, Age distribution	Population structure is important because of the reproductive strategy and life history traits of the turtle: - delayed sexual maturity - small clutch size - low reproductive success - high adult survival rates - long adult lives (Lee 1999)	Based on conversation with Jim Harding and MNFI abstract.	A good rating would entail improved recruitment of young turtles and a more evenly distributed population age structure.
Rare turtles of concern, Condition, Population structure and recruitment for Glyptemys insculpta, Age distribution	Population structure is important because of the reproductive strategy and life history traits of the turtle: - delayed sexual maturity - small clutch size - low reproductive success - high adult survival rates - long adult lives (Lee 1999)	Based on conversation with Jim Harding and MNFI abstract.	A good rating would entail improved recruitment of young turtles and a more evenly distributed population age structure.
Rare turtles of concern, Size, Abundance of Emys blandingii, Number of occurrences	MNFI tracks species and assigns ranks depending on the number of occurrences.	Based on conversation with Jim Harding and MNFI abstract.	A good rating would entail improved recruitment of young turtles and protection of current adults and their breeding sites.

Conservation Target, Category, Key Attribute, Indicator	**Key attribute and indicator comment**	**Current rating comment**	**Desired rating comment**
Rare turtles of concern, Size, Abundance of Glyptemys insculpta, Number of occurrences	MNFI tracks species and assigns ranks depending on the number of occurrences.	Based on conversation with Jim Harding and MNFI abstract.	A good rating would entail improved recruitment of young turtles and protection of current adults and their breeding sites.
Sistrurus catenatus catenatus, Landscape Context, Connectivity among occurrences, Distance between conservation areas	Connectivity is important to prevent inbreeding, bottleneck, and population decline and to promote genetic transfer between populations. (Yu Man Lee and Bruce Kingsbury)	best estimate (using conversations with Yu Man Lee and Bruce Kingsbury)	A good rating would mean increased knowledge of connectivity and making sure that a majority of the existing populations are close enough to maintain genetic diversity. A very good rating is unobtainable because of the fragmentation of habitat in the Grayling Subdistrict (for example, the snakes will not cross paved roads). (Kingsbury)
Sistrurus catenatus catenatus, Condition, Habitat extent, Number of acres of habitat	Habitat extent was suggested by Yu Man Lee and Bruce Kingsbury as an indirect method of assessing population viability.	Conversations with Yu Man Lee, Bruce Kingsbury, and Paul Thompson.	The rating of very good is necessary because the Grayling Subdistrict are considered a stronghold for the entire species.

Conservation Target, Category, Key Attribute, Indicator	Key attribute and indicator comment	Current rating comment	Desired rating comment
Sistrurus catenatus catenatus, Condition, Habitat quality, Mosaic habitat	Habitat quality was suggested by Yu Man Lee and Bruce Kingsbury as an indirect method of assessing population viability. Massasaugas require a mosaic habitat type of wetlands adjacent to uplands. The three main components of this habitat are "open, sunny areas intermixed with shaded areas (1) open, sunny areas intermixed with shaded areas, presumably for thermoregulation; (2) presence of the water table near the surface for hibernation; and (3) variable elevations between adjoining lowland and upland habitats" (MNFI Abstract).	Conversations with Yu Man Lee, Paul Thompson, and Bruce Kingsbury.	The rating of very good is necessary because the Grayling Subdistrict are considered a stronghold for the entire species.
Sistrurus catenatus catenatus, Condition, Population structure & recruitment , Age distribution	Recruitment was suggested by Yu Man Lee as a method of assessing population viability.	Conversation with Yu Man Lee USFWS Status Assessment	A good rating would mean increased knowledge of population structure and ensuring continued recruitment. A very good rating is unobtainable because of road mortality and poaching.
Sistrurus catenatus catenatus, Size, Population size, Number of occurrences	This is the measure by which MNFI and U.S. Fish and Wildlife Service assess the status of the species.	Conversation with Yu Man Lee and Bruce Kingsbury, MNFI Abstract, USFWS Status Assessment (1998)	Northern Michigan may be one of the last remaining places capable of supporting a metapopulation of massasaugas. Historically, there were over 200 occurrences of massasaugas known in the state of Michigan and 139 are extant. (USFWS Status Assessment)

Conservation Target, Category, Key Attribute, Indicator	**Key attribute and indicator comment**	**Current rating comment**	**Desired rating comment**
Appalachia arcana, Size, Abundance of Appalachia arcana, Number of occurrences	MNFI tracks species and assigns ranks depending on the number of occurrences.	best guess, MNFI occurrence database	A good rating would entail the conservation of the current 39 occurrences and identification and conservation of any other existing occurrences.

Stresses and Sources Summary

1	Jack pine barrens

Viability Summary	Landscape Context	Condition	Size	Viability Rank
	Poor	Fair	Poor	Poor

	Stresses - Altered Key Ecological Attributes	Severity	Scope	Stress Rank	User Override
1	Altered fire regime	Very High	Very High	Very High	
2	Altered spatial occurrence pattern	High	Very High	High	
3	Introduction and abundance of invasive species	Medium	Medium	Medium	
4	Dominance of native increasers	High	Very High	High	
5	Altered species composition	Low	Low	Low	
6	Reduced size/extent of characteristic jack pine barrens	Very High	Very High	Very High	
7				-	
8				-	

1. Jack pine barrens

Threats - Sources of Stress	Altered fire regime	Altered spatial occurrence pattern	Introduction and abundance of invasive species	Dominance of native increasers	Altered species composition	Reduced size/extent of characteristic jack pine barrens
Stress Rank	*Very High*	*High*	*Medium*	*High*	*Low*	*Very High*

1. Fire suppression

Threat to System Rank: Very High

Contribution	Very High	High	Medium	Low	Very High	Very High
Irreversibility	High	High	High	High	High	High
Threat Rank (override)						
Threat Rank	Very High	High	Low	Medium	Low	Very High

2. Timber plantations

Threat to System Rank: Very High

Contribution		Very High	Medium		High	Very High
Irreversibility		Low	High		Medium	Low
Threat Rank (override)						
Threat Rank	-	High	Low	-	Low	Very High

3. Kirtland's warbler management areas

Threat to System Rank: High

Contribution	Medium	Low			High	Medium
Irreversibility	High	Medium			Medium	Medium
Threat Rank (override)						
Threat Rank	High	Low	-	-	Low	High

1. Jack pine barrens *continued*

Threats - Sources of Stress	Altered fire regime	Altered spatial occurrence pattern	Introduction and abundance of invasive species	Dominance of native increasers	Altered species composition	Reduced size/extent of characteristic jack pine barrens
Stress Rank	*Very High*	*High*	*Medium*	*High*	*Low*	*Very High*

4. Roads

Threat to System Rank: High

Contribution	High		Very High			Medium
Irreversibility	Very High		Very High			Very High
Threat Rank (override)	Medium					Medium
Threat Rank	High	-	Medium	-	-	High

5. Development

Threat to System Rank: Medium

Contribution	High	Medium	High		-	High
Irreversibility	Very High	Very High	Very High		-	Very High
Threat Rank (override)	Low	Medium				Low
Threat Rank	Medium	Medium	Medium	-	-	Medium

6. Off-road vehicles

Threat to System Rank: Medium

Contribution			High			
Irreversibility			High			
Threat Rank (override)						
Threat Rank	-	-	Medium	-	-	-

2	Dry sand prairie

Viability Summary	Landscape Context	Condition	Size	Viability Rank
	Poor	Poor	Poor	Poor

	Stresses - Altered Key Ecological Attributes	Severity	Scope	Stress Rank	User Override
1	Altered fire regime	Very High	Very High	Very High	
2	Soil degradation	High	Medium	Medium	
3	Introduction and abundance of invasive species	Medium	Medium	Medium	
4	Altered species composition	Low	Low	Low	
5	Reduced size/extent of characteristic dry sand prairies	Very High	Very High	Very High	
6				-	
7				-	
8				-	

2. Dry sand prairie

Threats - Sources of Stress	Altered fire regime	Soil degradation	Introduction and abundance of invasive species	Altered species composition	Reduced size/extent of characteristic dry sand prairies
Stress Rank	*Very High*	*Medium*	*Medium*	*Low*	*Very High*

1. Fire suppression

Threat to System Rank: Very High

Contribution	Very High	Medium	High	High	Very High
Irreversibility	High	High	High	High	High
Threat Rank (override)					
Threat Rank	Very High	Low	Medium	Low	Very High

2. Timber plantations

Threat to System Rank: Very High

Contribution		High	Medium	High	Very High
Irreversibility		Very High	High	Medium	Medium
Threat Rank (override)					
Threat Rank	-	Medium	Low	Low	Very High

3. Development

Threat to System Rank: Medium

Contribution	High	High	High		Medium
Irreversibility	Very High	Very High	High		Very High
Threat Rank (override)	Low				Low
Threat Rank	Medium	Medium	Medium	-	Medium

2. Dry sand prairie *continued*

Threats - Sources of Stress	Altered fire regime	Soil degradation	Introduction and abundance of invasive species	Altered species composition	Reduced size/extent of characteristic dry sand prairies
Stress Rank	*Very High*	*Medium*	*Medium*	*Low*	*Very High*

4. Roads

Threat to System Rank: High

Contribution	High	Medium	Very High		Medium
Irreversibility	Very High	Very High	Very High		Very High
Threat Rank (override)	Medium				Medium
Threat Rank	High	Medium	Medium	-	High

5. Kirtland's warbler management areas

Threat to System Rank: High

Contribution	Medium	Medium		Low	Medium
Irreversibility	Medium	High		High	Medium
Threat Rank (override)					
Threat Rank	High	Low	-	Low	High

6. Off-road vehicles

Threat to System Rank: Medium

Contribution		High	High		
Irreversibility		High	High		
Threat Rank (override)					
Threat Rank	-	Medium	Medium	-	-

3	Wetlands

Viability Summary	Landscape Context	Condition	Size	Viability Rank
	Poor	Poor	Good	Fair

	Stresses - Altered Key Ecological Attributes	Severity	Scope	Stress Rank	User Override
1	Altered fire regime	Medium	Very High	Medium	
2	Altered hydrologic regime	Medium	Medium	Medium	
3	Introduction and abundance of invasive species	High	High	High	
4	Decline of species of conservation concern	Medium	Medium	Medium	
5	Reduced size/extent of characteristic wetlands	High	High	High	
6				-	
7				-	
8				-	

3. Wetlands

Threats - Sources of Stress	Altered fire regime	Altered hydrologic regime	Introduction and abundance of invasive species	Decline of species of conservation concern	Reduced size/extent of characteristic wetlands
Stress Rank	*Medium*	*Medium*	*High*	*Medium*	*High*

1. Fire suppression

Threat to System Rank: High

Contribution	Very High		Medium	Medium	High
Irreversibility	High		High	High	High
Threat Rank (override)					
Threat Rank	Medium	-	Medium	Low	High

2. Development

Threat to System Rank: High

Contribution	Low	Very High	Medium	Medium	High
Irreversibility	High	Very High	High	High	High
Threat Rank (override)					
Threat Rank	Low	Medium	Medium	Low	High

3. Roads

Threat to System Rank: High

Contribution	High	Very High	High		Medium
Irreversibility	High	Very High	High		High
Threat Rank (override)					
Threat Rank	Medium	Medium	High	-	Medium

3. Wetlands *continued*

Threats - Sources of Stress	Altered fire regime	Altered hydrologic regime	Introduction and abundance of invasive species	Decline of species of conservation concern	Reduced size/extent of characteristic wetlands
Stress Rank	*Medium*	*Medium*	*High*	*Medium*	*High*

4. Off-road vehicles

Threat to System Rank: High

Contribution			High	Medium	
Irreversibility			High	High	
Threat Rank (override)					
Threat Rank	-	-	High	Low	-

4	Rare turtles of concern

Viability Summary	Landscape Context	Condition	Size	Viability Rank
	-	Poor	Poor	Poor

	Stresses - Altered Key Ecological Attributes	Severity	Scope	Stress Rank	User Override
1	Altered population structure and recruitment for Emys blandingii	High	High	High	
2	Declining population of Emys blandingii	Medium	Medium	Medium	
3	Altered population structure and recruitment for Glyptemys insculpta	Very High	Very High	Very High	
4	Declining population of Glyptemys insculpta	High	High	High	
5	Habitat loss and degradation for Emys blandingii	High	High	High	
6	Habitat loss and degradation for Glyptemys insculpta	Medium	Medium	Medium	
7				-	
8				-	

4. Rare turtles of concern

Threats - Sources of Stress	Altered population structure and recruitment for Emys blandingii	Declining population of Emys blandingii	Altered population structure and recruitment for Glyptemys insculpta	Declining population of Glyptemys insculpta	Habitat loss and degradation for Emys blandingii	Habitat loss and degradation for Glyptemys insculpta
Stress Rank	*High*	*Medium*	*Very High*	*High*	*High*	*Medium*

1. Roads

Threat to System Rank: High

Contribution	Very High	Very High	Low	Low		
Irreversibility	High	High	High	High		
Threat Rank (override)						
Threat Rank	High	Medium	High	Medium	-	-

2. Development

Threat to System Rank: Medium

Contribution					Medium	Medium
Irreversibility					High	High
Threat Rank (override)						
Threat Rank	-	-	-	-	Medium	Low

3. Increased predation by raccoons

Threat to System Rank: Very High

Contribution	Very High	Very High	Very High	Very High		
Irreversibility	High	High	High	High		
Threat Rank (override)						
Threat Rank	High	Medium	Very High	High	-	-

4. Rare turtles of concern *continued*

Threats - Sources of Stress	Altered population structure and recruitment for Emys blandingii	Declining population of Emys blandingii	Altered population structure and recruitment for Glyptemys insculpta	Declining population of Glyptemys insculpta	Habitat loss and degradation for Emys blandingii	Habitat loss and degradation for Glyptemys insculpta
Stress Rank	*High*	*Medium*	*Very High*	*High*	*High*	*Medium*

4. Poaching

Threat to System Rank: Very High

Contribution	High	High	Very High	Very High		
Irreversibility	High	High	High	High		
Threat Rank (override)						
Threat Rank	High	Medium	Very High	High	-	-

5	Sistrurus catenatus catenatus

Viability Summary	Landscape Context	Condition	Size	Viability Rank
	Fair	Fair	Fair	Fair

	Stresses - Altered Key Ecological Attributes	Severity	Scope	Stress Rank	User Override
1	Decreased connectivity among occurrences	High	High	High	
2	Reduction in high quality habitat (loss of open uplands and adjacent wetlands)	Very High	Very High	Very High	
3	Limited recruitment	Medium	High	Medium	
4	Increased adult mortality	High	High	High	
5	Decreased population size	Medium	High	Medium	
6		-	-	-	
7				-	
8				-	

5. Sistrurus catenatus catenatus

Threats - Sources of Stress	Decreased connectivity among occurrences	Reduction in high quality habitat (loss of open uplands and adjacent wetlands)	Limited recruitment	Increased adult mortality	Decreased population size
Stress Rank	*High*	*Very High*	*Medium*	*High*	*Medium*

1. Fire suppression

Threat to System Rank: Very High

Contribution		Very High			
Irreversibility		High			
Threat Rank (override)					
Threat Rank	-	Very High	-	-	-

2. Timber plantations

Threat to System Rank: High

Contribution	-	High			
Irreversibility	-	Medium			
Threat Rank (override)					
Threat Rank	-	High	-	-	-

3. Roads

Threat to System Rank: Very High

Contribution	High	Low	Medium	High	High
Irreversibility	High	High	High	High	High
Threat Rank (override)					
Threat Rank	High	High	Low	High	Medium

5. Sistrurus catenatus catenatus *continued*

Threats - Sources of Stress	Decreased connectivity among occurrences	Reduction in high quality habitat (loss of open uplands and adjacent wetlands)	Limited recruitment	Increased adult mortality	Decreased population size
Stress Rank	*High*	*Very High*	*Medium*	*High*	*Medium*

4. Development

Threat to System Rank: High

Contribution	Medium	Low			
Irreversibility	High	High			
Threat Rank (override)					
Threat Rank	Medium	High	-	-	-

5. Poaching

Threat to System Rank: High

Contribution			Medium	High	High
Irreversibility			Very High	Very High	Very High
Threat Rank (override)					
Threat Rank	-	-	Medium	High	Medium

6. Prescribed fire during the snake's active season

Threat to System Rank: Medium

Contribution					High
Irreversibility					High
Threat Rank (override)					
Threat Rank	-	-	-	-	Medium

5. Sistrurus catenatus catenatus *continued*

Threats - Sources of Stress	Decreased connectivity among occurrences	Reduction in high quality habitat (loss of open uplands and adjacent wetlands)	Limited recruitment	Increased adult mortality	Decreased population size
Stress Rank	*High*	*Very High*	*Medium*	*High*	*Medium*

7. Disking and mowing

Threat to System Rank: Medium

Contribution					High
Irreversibility					High
Threat Rank (override)					
Threat Rank	-	-	-	-	Medium

8. Injury and premature death due to human persecution

Threat to System Rank: High

Contribution			Medium	High	High
Irreversibility			High	High	High
Threat Rank (override)					
Threat Rank	-	-	Low	High	Medium

6	Appalachia arcana

Viability Summary	Landscape Context	Condition	Size	Viability Rank
	-	-	Fair	Fair

	Stresses - Altered Key Ecological Attributes	Severity	Scope	Stress Rank	User Override
1	Habitat loss and degradation	Medium	Medium	Medium	
2	Excessive mortality	Medium	Medium	Medium	
3				-	
4				-	
5				-	
6				-	
7				-	
8				-	

6. Appalachia arcana

Threats - Sources of Stress	Habitat loss and degradation	Excessive mortality
Stress Rank	*Medium*	*Medium*

1. Roads

Threat to System Rank: Low

Contribution	Medium	
Irreversibility	High	
Threat Rank (override)		
Threat Rank	Low	-

2. Pesticides

Threat to System Rank: Low

Contribution		Medium
Irreversibility		High
Threat Rank (override)		
Threat Rank	-	Low

3. Development

Threat to System Rank: Low

Contribution	Medium	
Irreversibility	High	
Threat Rank (override)		
Threat Rank	Low	-

6. Appalachia arcana

Threats - Sources of Stress	Habitat loss and degradation	Excessive mortality
Stress Rank	*Medium*	*Medium*

4. Logging

Threat to System Rank: Low

Contribution	Medium	
Irreversibility	Medium	
Threat Rank (override)		
Threat Rank	Low	-

Threats Summary Table

Threats Across Systems		Jack pine barrens	Dry sand prairie	Wetlands	Rare turtles of concern	Sistrurus catenatus catenatus	Appalachia arcana	Overall Threat Rank
Project-specific threats								
1	Fire suppression	Very High	Very High	High	-	Very High	-	Very High
2	Roads	High	High	High	High	Very High	Low	Very High
3	Timber plantations	Very High	Very High	-	-	High	-	Very High
4	Poaching	-	-	-	Very High	High	-	High
5	Increased predation by raccoons	-	-	-	Very High	-	-	High
6	Development	Medium	Medium	High	Medium	High	Low	High
7	Kirtland's warbler management areas	High	High	-	-	-	-	High
8	Off-road vehicles	Medium	Medium	High	-	-	-	Medium
9	Injury and premature death due to human persecution	-	-	-	-	High	-	Medium
10	Disking and mowing	-	-	-	-	Medium	-	Low
11	Prescribed fire during the snake's active season	-	-	-	-	Medium	-	Low
12	Pesticides	-	-	-	-	-	Low	Low
13	Logging	-	-	-	-	-	Low	Low
14		-	-	-	-	-	-	-
15		-	-	-	-	-	-	-
16		-	-	-	-	-	-	-
Threat Status for Targets and Site		Very High	Very High	High	Very High	Very High	Low	Very High

Conservation Targets		Landscape Context		Condition		Size		Viability Rank
		Grade	Weight	Grade	Weight	Grade	Weight	
1	Jack pine barrens	Poor	1	Fair	1	Poor	1	**Poor**
2	Dry sand prairie	Poor	1	Poor	1	Poor	1	**Poor**
3	Wetlands	Poor	1	Poor	1	Good	1	**Fair**
4	Rare turtles of concern	-	1	Poor	1	Poor	1	**Poor**
5	Sistrurus catenatus catenatus	Fair	1	Fair	1	Fair	1	**Fair**
6	Appalachia arcana	-	1	-	1	Fair	1	**Fair**
7		-	1	-	1	-	1	**-**
8		-	1	-	1	-	1	**-**
Site Biodiversity Health Rank								**Fair**

Objectives and Strategic Actions Table

#	Objectives and Strategic Actions
Objective 1	**By December 2006, initiate the implementation of this plan.**
Strategic action	Secure funding for two years to initiate the implementation of the plan.
Strategic action	Hire a staff person to coordinate the implementation of this plan and identify future funding sources.
Strategic action	Conduct a scoping meeting with stakeholders to refine how TNC can work with them.
Objective 2	**By 2008, establish a collaborative working group with agency personnel, private landowners, and other stakeholders to address threats and ensure the conservation of targets.**
Strategic action	By 2007, conduct two initial meetings to gauge interest in establishing a working group.
Strategic action	By 2008, draft key goals and objectives of the Grayling working group.
Objective 3a	**By 2030, achieve a "good" ranking for fire regime in jack pine barrens, dry sand prairie, and wetlands of the Grayling Subdistrict, as defined in the viability analysis.**
Strategic action	Develop a regional fire management plan with annual acreage goals for the Grayling Subdistrict.
Strategic action	Develop a Memorandum of Understanding or mutual agreement with the USDA Forest Service and the MI DNR to allow for personnel to conduct prescribed fires across land ownership boundaries.
Strategic action	Increase the short-term capacity for prescribed fire by hiring a seasonal fire crew and increase long-term capacity by recruiting and training local people in prescribed fire.
Strategic action	Encourage the Michigan Prescribed Fire Council to hold their annual meeting in the Grayling Subdistrict and conduct a demonstration burn at Camp Grayling.
Strategic action	By 2008, use LANDFIRE data to prioritize recommendations for areas that need to be burned.
Strategic action	By 2010, identify a site-based project in the Grayling Subdistrict to include in the regional Laurentian Mixed Forest U.S. Fire Learning Network.

#	Objectives and Strategic Actions
Objective 3b	**By 2020, ensure that at least 12,000 acres of jack pine barrens and 600 acres of dry sand prairie are restored across the Grayling Subdistrict.**
Strategic action	Position TNC staff to become an integral part of the ecoregional plan development for northern Lower Michigan by the end of 2007.
Strategic action	Using historical distribution and fire data, identify potential areas for jack pine barrens and dry sand prairie restoration.
Strategic action	Work with Brian Piccolo and other LIP program administrators to encourage local private landowners to restore jack pine barrens and other ecosystems in the Grayling Subdistrict.
Strategic action	Determine TNC's role in the implementation of the Camp Grayling Pine Barrens Restoration Plan.
Objective 4a	**Support and/or undertake additional research on the species and ecosystems of the Grayling Subdistrict.**
Strategic action	Commission MNFI ecologists to conduct entomology studies on insects of concern in the Grayling Subdistrict.
Strategic action	Work with the University of Michigan Biological Station to facilitate student research of target species in the Grayling Subdistrict.
Strategic action	Identify and/or purchase land that can be used as a demonstration area for ecosystem-based Kirtland's warbler management.
Strategic action	Assist in funding a PhD or post-doctoral fellow to do research on ecosystem-based management for the Kirtland's warbler.
Strategic action	By 2012, set up a demonstration Kirtland's warbler management area to determine the suitability of jack pine barrens and different jack pine planting patterns for the Kirtland's warbler.
Objective 4b	**By 2010, partner with at least 3 organizations to provide environmental education and outreach to aid the conservation of the Grayling Subdistrict communities and rare species.**
Strategic action	Assist the Stewardship Network in establishing a cluster in the Grayling Subdistrict.
Strategic action	Work with partners to disseminate information on the role of fire in the natural ecosystems of the subdistrict.
Strategic action	Work with the MNFI to disseminate information on Sistrurus catenatus catenatus to nature centers and other public recreational facilities.
Strategic action	Work with partners to disseminate information on the impacts of collecting wild reptiles.

#	Objectives and Strategic Actions
Objective 5a	**By 2010, ensure the protection of the high quality wetlands at Camp Grayling including the mesic sand prairie wetland complex (Portage Creek-Howes Lake Complex) with populations of Solidago houghtonii.**
Strategic action	Designate the high quality natural communities at Camp Grayling as a State Natural Areas or state-designated High Conservation Value Areas.
Objective 5b	**By 2015, decrease the threat level of incompatible land management practices on Sistrurus catenatus catenatus.**
Strategic action	Identify and educate private landowners who have populations of Sistrurus catenatus catenatus on their property about the Candidate Conservation Agreement with Assurances.
Strategic action	Identify areas where incompatible land management practices are a threat to Sistrurus catenatus catenatus.
Strategic action	Educate practitioners about the effects of prescribed burning on Sistrurus catenatus catenatus
Objective 6a	**By 2010, ensure protection of isolated wetlands less than 5 acres in size on private and public lands.**
Strategic action	Work with the Department of Environmental Quality to pass legislation to ensure that isolated wetlands are incorporated into the current wetlands protection legislation.
Strategic action	Work with local units of government in the Grayling Subdistrict to develop and enact local wetland ordinances.
Objective 6b	**Reduce the negative impacts of roads and development on the targets.**
Strategic action	Work with the USDA Forest Service and MI DNR to consolidate their landholdings to help reduce fragmentation by roads.
Strategic action	Encourage the MI DNR to conduct a roads analysis similar to the USDA Forest Service's 2002 Roads Analysis for the Huron-Manistee National Forests to determine if they can decommission or improve any roads in the subdistrict.
Strategic action	Work with biologists to identify areas for seasonal road closure and signage based on wildlife movement.

#	Objectives and Strategic Actions
Objective 6c	**Work with the MI DNR to reduce the impact of illegal ORV use on public lands.**
Strategic action	Help disseminate information about the MI DNR ORV Trail Maintenance and Restoration grants to appropriate groups for restoration of target ecosystems.
Strategic action	Work with the DNR and partner organizations to incorporate education about the impacts of ORVs on ecosystems into existing safety education programs.
Strategic action	Provide information on the impacts of ORVs on our target ecosystems to all ORV licensees.

Appendix C: Project Contact List

Name	Title	Address	Phone	E-mail	Contact	Area of Focus
Doug Pearsall	The Nature Conservancy East Michigan Science and Planning Director	The Nature Conservancy 101 E. Grand River Lansing, MI 48906	(517) 316-2259	dpearsall@tnc.org	Project Client	
John Legge	The Nature Conservancy West Michigan Conservation Director	The Nature Conservancy 3728 West River Drive, NE, Comstock Park, MI 49321	(616) 785-7055 ext. 12	jlegge@tnc.org	Conference call 12/21/05	
Kenneth "Rex" Ennis	USDA Forest Service Wildlife Biologist	USDA Forest Service Huron Manistee NF 1755 South Mitchell St. Cadillac, MI 49601	(231) 775-2421	kennis@fs.fed.us	Meeting 4/15/05	Huron NF management plan
Paul Thompson	USDA Forest Service Wildlife Biologist	USDA Forest Service Huron Manistee NF 5761 N. Skeel Road Oscoda, MI 48750	(989) 739-0728 ext. 3028	pdthompson@fs.fed.us	Meeting 4/15/05; Phone Interview 1/5/06	Eastern massasauga
Alix Cleveland	USDA Forest Service Forest Plant Ecologist, NNIS Coordinator	USDA Forest Service Huron-Manistee NF 1755 South Mitchell St. Cadillac, MI 49601	(231) 775-5023 ext. 8729	acleveland@fs.fed.us	Phone Interview 11/23/05	Plants of the Grayling Subdistrict
Phil Huber	USDA Forest Service Wildlife Biologist	USDA Forest Service Huron Manistee NF 401 N. Court St. Mio, MI 48647	(989) 826-3252 ext. 3316	phuber@fs.fed.us	Meeting 5/13/2005; Phone Interview 11/16/05	Jack pine barrens, dry sand prairies, Kirtland's warbler management
Greg J. Schmidt	USDA Forest Service Botanist	USDA Forest Service Huron Manistee NF 401 N. Court St. Mio, MI 48647	(989) 826-3252 ext. 3319	gjschmidt@fs.fed.us	Meeting 5/13/2005; Phone Interview 11/14/05	Plants of the Grayling Subdistrict
Mark Boersen	MI DNR Wildlife Habitat Biologist	MI DNR - Roscommon Operations Service Center 8717 N. Roscommon Rd. Roscommon, MI 49653	(989) 275-5151 ext. 2730	boersenm@michigan.gov	Meeting 4/22/2005	
Elaine Carlson	MI DNR Wildlife Biologist	MI DNR-	(989) 826-3211 ext. 7030	carlsone@michigan.gov	Meeting 4/22/2005	Kirtland's warbler recovery efforts
Keith Kintigh	MI DNR Wildlife Ecologist	MI DNR - Gaylord Operations Service Center 1732 West M-32 Gaylord, Michigan 49735	(989) 732-3541 ext. 5031	kintighk@michigan.gov	Meeting 4/22/2005	
Brian Piccolo	MI DNR Wildlife Habitat Biologist	MI DNR - Roscommon Operations Service Center 8717 N. Roscommon Rd. Roscommon, MI 49653	(989) 275-5151 ext. 2030	piccolob@michigan.gov	Meeting 4/22/2005; Phone Interview 11/21/05	Jack pine barrens, Landowner Incentive Program, private lands strategies

Name	Title	Address	Phone	E-mail	Contact	Area of Focus
Ed Schools	MNFI Program Leader – Conservation & GIS	Michigan Natural Features Inventory P.O. Box 30444 Lansing, MI 48909-7944	(517) 373-0798	schoolse@ michigan.gov	Meeting 03/2005	MNFI biotics database
Mike Penskar	MNFI Program Leader, Botany	Michigan Natural Features Inventory P.O. Box 30444 Lansing, MI 48909-7944	(517) 335-4582	penskarm@ michigan.gov	Phone Interview 12/9/05	Natural communities and plants
Mike A. Kost	MNFI Program Leader, Ecology	Michigan Natural Features Inventory P.O. Box 30444 Lansing, MI 48909-7944	(517) 373-4817	kostma@ michigan.gov	Phone Interview 11/18/06	Jack pine barrens
Phyllis J. Higman	MNFI Associate Program Leader, Botany	Michigan Natural Features Inventory P.O. Box 30444 Lansing, MI 48909-7944	(517) 373-6983	higmanp@ michigan.gov	Phone Interview 1/17/06	Plants of the Grayling Subdistrct; Camp Grayling
Yu Man Lee	MNFI Associate Program Leader, Zoology	Michigan Natural Features Inventory P.O. Box 30444 Lansing, MI 48909-7944	(517) 373-3751	leeyu@michigan. gov	Phone Interview 11/16/06	Eastern massasauga
Larry Jacobs	Michigan Military Affairs Environment Program		(989) 344-6175		Phone Interview 11/15/06	Camp Grayling, populations of *Solidago houghtonii*
Bruce Kingsbury	Center for Reptile and Amphibian Conservation Director	Center for Reptile and Amphibian Conservation and Management Indiana-Purdue University 2101 E. Coliseum Blvd. Fort Wayne, IN 46805-1499	(260) 481-5755	herps@ipfw.edu	Phone Interview 11/15/06	Eastern massasauga, Camp Grayling massasaugas
James H. Harding	Instructor/ Herpetology Specialist	Michigan State University Dept. of Zoology - Museum 205A Museum West Circle Drive East Lansing, MI 48824	(517) 353-7978	hardingi@pilot. msu.edu	Phone Interview 1/6/06	Blanding's turtle, Wood turtle
Meredith Cornett	The Nature Conservancy of Minnesota - Director of Conservation Science	Northeast Minnesota Office 394 Lake Avenue South, Suite 308 Duluth, MN 55802	(218) 727-0185		N/A	Border Lakes Partnership
Daniel J. Stynes	Michigan State University - Professor Emeritus	Department of Community, Agriculture, Recreation, and Resource Studies, 131 Natural Resources, East Lansing, MI 48824	(517) 353-9881	stynes@msu.edu	Phone Interview 1/13/06	Private land owners, recreation

Appendix D: Change Levels of Landcover Type (1800-2000)

Barrens/Grassland				
Value	**FROM (1800)**	**TO (2000)**	**CHANGE_ LEVEL**	**DESCRIPTION**
1063	Grassland	Herbaceous Openland	1	Cover type unchanged
1200	Grassland	Sand / Soil	1	Cover type unchanged
1060	Grassland	Aspen Association	2	Minor change in cover type
1072	Grassland	Lowland Shrub	2	Minor change in cover type
1064	Grassland	Mixed Non-Forest Wetland	2	Minor change in cover type
1068	Grassland	Mixed Upland Deciduous	2	Minor change in cover type
1067	Grassland	Oak Association	2	Minor change in cover type
1066	Grassland	Upland Shrub / Low-density trees	2	Minor change in cover type
783	Oak/Pine Barrens	Sand / Soil	1	Cover type unchanged
792	Oak/Pine Barrens	Upland Shrub / Low-density trees	1	Cover type unchanged
786	Oak/Pine Barrens	Mixed Upland Conifers	2	Minor change in cover type
785	Oak/Pine Barrens	Oak Association	2	Minor change in cover type
1198	Oak/Pine Barrens	Other Upland Conifers	2	Minor change in cover type
782	Oak/Pine Barrens	Pines	2	Minor change in cover type
784	Oak/Pine Barrens	Upland Mixed Forest	2	Minor change in cover type
877	Pine Barrens	Sand / Soil	1	Cover type unchanged
826	Pine Barrens	Upland Shrub / Low-density trees	1	Cover type unchanged
839	Pine Barrens	Mixed Upland Conifers	2	Minor change in cover type
831	Pine Barrens	Oak Association	2	Minor change in cover type
1112	Pine Barrens	Other Upland Conifers	2	Minor change in cover type
833	Pine Barrens	Pines	2	Minor change in cover type

Nonforested Wetlands				
Value	**FROM (1800)**	**TO (2000)**	**CHANGE_ LEVEL**	**DESCRIPTION**
349	Muskeg/Bog	Lowland Coniferous Forest	1	Cover type unchanged
476	Muskeg/Bog	Lowland Coniferous Forest	1	Cover type unchanged
330	Muskeg/Bog	Lowland Shrub	1	Cover type unchanged
472	Muskeg/Bog	Lowland Shrub	1	Cover type unchanged
328	Muskeg/Bog	Mixed Non-Forest Wetland	1	Cover type unchanged
464	Muskeg/Bog	Mixed Non-Forest Wetland	1	Cover type unchanged
329	Muskeg/Bog	Emergent Wetland	2	Minor change in cover type
473	Muskeg/Bog	Emergent Wetland	2	Minor change in cover type
346	Muskeg/Bog	Floating Aquatic	2	Minor change in cover type
550	Muskeg/Bog	Floating Aquatic	2	Minor change in cover type
353	Muskeg/Bog	Lowland Mixed Forest	2	Minor change in cover type
483	Muskeg/Bog	Lowland Mixed Forest	2	Minor change in cover type
348	Muskeg/Bog	Upland Shrub / Low-density trees	2	Minor change in cover type
486	Muskeg/Bog	Upland Shrub / Low-density trees	2	Minor change in cover type
47	Shrub Swamp/Emergent Marsh	Emergent Wetland	1	Cover type unchanged
406	Shrub Swamp/Emergent Marsh	Emergent Wetland	1	Cover type unchanged
757	Shrub Swamp/Emergent Marsh	Emergent Wetland	1	Cover type unchanged
46	Shrub Swamp/Emergent Marsh	Floating Aquatic	1	Cover type unchanged
594	Shrub Swamp/Emergent Marsh	Floating Aquatic	1	Cover type unchanged
755	Shrub Swamp/Emergent Marsh	Floating Aquatic	1	Cover type unchanged
1121	Shrub Swamp/Emergent Marsh	Floating Aquatic	1	Cover type unchanged
44	Shrub Swamp/Emergent Marsh	Lowland Shrub	1	Cover type unchanged
403	Shrub Swamp/Emergent Marsh	Lowland Shrub	1	Cover type unchanged
750	Shrub Swamp/Emergent Marsh	Lowland Shrub	1	Cover type unchanged
1105	Shrub Swamp/Emergent Marsh	Lowland Shrub	1	Cover type unchanged
45	Shrub Swamp/Emergent Marsh	Mixed Non-Forest Wetland	1	Cover type unchanged
404	Shrub Swamp/Emergent Marsh	Mixed Non-Forest Wetland	1	Cover type unchanged

Value	FROM (1800)	TO (2000)	CHANGE_ LEVEL	DESCRIPTION
907	Shrub Swamp/Emergent Marsh	Mixed Non-Forest Wetland	1	Cover type unchanged
1104	Shrub Swamp/Emergent Marsh	Mixed Non-Forest Wetland	1	Cover type unchanged
213	Shrub Swamp/Emergent Marsh	Lowland Coniferous Forest	2	Minor change in cover type
402	Shrub Swamp/Emergent Marsh	Lowland Coniferous Forest	2	Minor change in cover type
753	Shrub Swamp/Emergent Marsh	Lowland Coniferous Forest	2	Minor change in cover type
1118	Shrub Swamp/Emergent Marsh	Lowland Coniferous Forest	2	Minor change in cover type
43	Shrub Swamp/Emergent Marsh	Lowland Deciduous Forest	2	Minor change in cover type
401	Shrub Swamp/Emergent Marsh	Lowland Deciduous Forest	2	Minor change in cover type
754	Shrub Swamp/Emergent Marsh	Lowland Deciduous Forest	2	Minor change in cover type
1107	Shrub Swamp/Emergent Marsh	Lowland Deciduous Forest	2	Minor change in cover type
48	Shrub Swamp/Emergent Marsh	Lowland Mixed Forest	2	Minor change in cover type
408	Shrub Swamp/Emergent Marsh	Lowland Mixed Forest	2	Minor change in cover type
1026	Shrub Swamp/Emergent Marsh	Lowland Mixed Forest	2	Minor change in cover type
1114	Shrub Swamp/Emergent Marsh	Lowland Mixed Forest	2	Minor change in cover type
49	Shrub Swamp/Emergent Marsh	Water	2	Minor change in cover type
405	Shrub Swamp/Emergent Marsh	Water	2	Minor change in cover type
904	Shrub Swamp/Emergent Marsh	Water	2	Minor change in cover type
1119	Shrub Swamp/Emergent Marsh	Water	2	Minor change in cover type

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