3 - Current Forest Conditions and Trends

3.1 – Introduction

The state forest satisfies many uses for the people of Michigan that can be divided into ecological, social and economic categories. Ecological uses or services include conservation of genetic diversity and wildlife habitat, regulation of water flow and quality, protection of soil quality and protection from erosion, air quality, climate modification and carbon sequestration. Social used include a feeling of spirituality or well-being associated forests, consumptive uses such as hunting, fishing, gathering and harvesting of forest products and non-consumptive uses including nature appreciation, camping and trail related activities (hiking, bicycles, off-road vehicles and horseback riding). Economic uses range from local community support through tourism and forest harvesting to oil and natural gas production and mining.

The forests of the northern Lower Peninsula can be classified by the types of forest communities on its diverse landforms formed by the last glacial period, each a result of the types of soil, availability of moisture and the types of plants and animals that adapted to those conditions. Much of the analysis and planning for this document was conducted using a regional landscape ecosystem classification system (Albert, 1995) that classifies the landscape into a hierarchy of useful and functional land units that differ from one another based on physical and biologic characteristics. Using various social, economic and ecological attributes of the state forest system, management areas are the basic ecological units that are used as a framework for the Northern Lower Peninsula Regional State Forest Management Plan.

The northern Lower Peninsula ecoregion ranges in elevation from 580 to 1,725 feet (near Cadillac) and has the largest end moraine features in the Lower Peninsula of Michigan. The climate is largely influenced by the Great Lakes. Most air masses cross the Great Lakes before entering the ecoregion, resulting in a more moderated climate compared to adjacent states. Compared to areas of equivalent latitude in Wisconsin and Minnesota, the northern Lower Peninsula ecoregion is warmer in winter and cooler in summer. Lake effect snow affects the ecoregion within 20 to 30 miles of the Great Lakes shorelines. The Highplains Subsection VII.2 (Albert, 1995) is the part of the ecoregion most distant from the Great Lakes and also the highest elevation. It has the most continental climatic conditions within the section: more summer precipitation, the greatest summer and winter temperature extremes, the shortest growing season and the greatest risk of spring freeze (Denton, 1985). Soils in the section range from sand to clay with sands (loamy sands and sandy loams) by far the most prevalent (U.S. Department of Agriculture Soil Conservation Service 1981, Albert, 1990). Almost all the soils are forest soils; that is, they developed their current characteristics in the presence of forest conditions. Presently, about 60% of the ecoregion remains forested.

3.2 Climate Change Impacts

Climate is as fundamental to forest communities as soil or hydrology. Since the 1980s the climate has been changing faster than it has in recorded history. The best available climate science indicates that past trends will continue. In that context, some impacts of these trends are very likely or virtually certain (Handler et al., In Press):

- Ecosystems will change across the landscape – this may include changes in location and/or changes in composition;
- Boreal and sub-boreal species are likely to be extirpated or increasingly isolated in cool lake-effect microclimates;
- Forest succession will likely change, making future trajectories increasingly unclear;
- Forest productivity will change, driven by changes in CO_2 fertilization, water and nutrient availability, local disturbances and species migration;
- Seasonal distribution of keystone species such as deer and wolves will change with decreasing snow fall and increased midwinter snow melt events;
- Exacerbation of existing threats and new interactions between threats are likely to be the most obvious effects of climate change; and
- Many current management objectives and practices will face substantial challenges.

Current (Observed) Climate Trends

Throughout the Midwest, average annual temperature has been increasing. The rate of that change has doubled since 1950 (Andresen et al., 2012). Winter and spring are warming faster than summer and fall and nighttime temperatures are warming faster than daytime temperatures (Andresen et al., 2012). Extreme heat events are more common (Andresen et al., 2012). Precipitation has also increased. The increase in recent years (1981-2010) has included a greater increase in winter and spring precipitation than summer and fall precipitation decreased. Both the frequencies of extreme precipitation events as well as the number of merely wet days have increased (Andresen et al., 2012).

Predicted Climate Trends

For the Midwest as a whole, there have been consistent projections for an increase in mean annual temperature and an increase in extreme heat events. Seasonal temperature projections are less consistent (Winkler et al., 2012). Projections for the northern Lower Peninsula suggest a greater increase in winter than summer (Handler et al., In Press and Swanston, 2011). However, overall temperature increases will likely be moderated by proximity to a Great Lake (Swanston, 2011).

Contrary to temperature projections, the precipitation projections are more consistent for seasonal patterns, but it is unknown if the average annual amount of precipitation will be an increase or decrease. Throughout Michigan the most consistent precipitation projections are for more winter precipitation, more rain instead of snow and more heavy precipitation events in every season (Winkler et al., 2012). For the northern Lower Peninsula there are differences between projections, depending on whether a low emissions scenario or a high emissions scenario is used in the models (Handler et al., In Press). The "*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis*" (Handler et al., In Press) describes sub-regional differences. However, there is a consistent projection for decreased snowfall outside of lake-effect areas and overall a change to more winter precipitation coming as rain (Hayhoe, 2010). Due to changes in the timing and volume of precipitation, all regions of Michigan will likely see significant changes in hydrologic regimes.

An additional trend expected in the short-term for the northern Lower Peninsula is an increase in soil frost depth due to reduced snowfall. However, in the long-term, the lack of snowfall will likely be off-set by warmer air temperatures and ultimately, soils are projected to be frozen for shorter periods in winter (Handler et al., In Press).

Potential Impacts to Forest Communities

Potential Impacts can be broken into categories, including 'Direct Impacts' (where change in a climatic variable has a direct effect on a species or ecosystem), 'Indirect Impacts' (where change in a climatic variable has an effect on some other factors that affects an species or ecosystem, typically by altering a disturbance regime) and 'Combined Impacts' (where changes in climatic variables cause complex interactions between factors that are already threats to the species or ecosystem).

Potential Direct Impacts:

- Increased temperatures resulting in reduced growth for some species and increased growth for others (Vose et. al., 2012); for those with potential to increase growth, this gain may be off-set by negative effects resulting from lack of synchronicity with other ecosystem or climatic variables (Swanston, 2011);
- Low soil moisture resulting in stress/mortality and affecting regeneration of trees and wetland wildlife (Vose et al., 2012);
- Extreme weather events resulting in stress/mortality, including longer dry seasons and more extreme floods (Vose et al., 2012);
- Increased atmospheric carbon dioxide and nitrogen deposition resulting in altered physiological function; much variation between species in response is expected (Vose et al., 2012);
- Changes in seasonal climatic factors resulting in longer growing seasons (Vose et al., 2012);
- Changes in multiple climatic factors resulting in reduced suitable habitat (spatial extent and/or quality) for some species; particularly for species associated with boreal forest systems, including quaking aspen, paper birch, tamarack, jack pine and black spruce (Handler et al., In Press); and
- Changes in multiple climatic factors resulting in increased suitable habitat (spatial extent and/or quality) for some species; particularly for species with ranges currently extending to the south, including American basswood, black cherry and white oak (Handler et al., In Press).

Potential Indirect Impacts:

- Pests, Disease and Invasive Species
    - Increased temperatures causing some pests and diseases to become more active; examples include beech bark disease, white pine blister rust, spruce budworm, tamarack sawfly, jack pine budworm, *Scleroderris*, white pine shoot weevil and red pine shoot blight (Handler et al., In Press);
    - Changes in multiple climatic factors causing some pests to expand in to new areas, particularly into areas with increased disturbance and dry forest ecosystems (Vose et al., 2012); examples include Asian longhorn beetle and western bark beetle (Handler et al., In Press); and

    - Changes in multiple climatic factors causing some invasive plants to increase and/or expand into new areas, with impacts particularly on regeneration; examples include buckthorn, honeysuckle, garlic mustard, reed canary grass, Japanese barberry, leafy spurge, spotted knapweed and St. John's wort (Handler et al., In Press).
- Moisture, Drought and Wildfire
    - Decreased snow cover causing even lower soil moisture (Vose et al., 2012);
    - Changes in multiple climatic factors causing increased drought and moisture stress, particularly late in the growing season (Handler et al., In Press and Swanston et al., 2011);
    - Changes in multiple climatic factors causing increased drought and wildfire, resulting in overall changes to structure and function of forest ecosystems (Vose et al., 2012);
    - Shifts in winter precipitation and temperature causing an advance in the timing of snowmelt runoff, resulting in changes to seasonal soil moisture and potentially increasing fire risk, depending on infiltration rates and soil frost (Handler et al., In Press); and
    - Increased temperatures causing accelerated decomposition of litter layers, resulting in lower water-holding capacity and greater moisture stress; this could prompt a move to barrens in some systems (Handler et al., In Press).
- Snowfall and Soil Frost
    - Changes in snowfall causing changes in soil frost that in turn affect water infiltration rates, nutrient cycling and tree growth (Handler et al., In Press); while short-term increases in soil frost depth due to decreases in snowfall may occur, long-term predictions suggest air temperatures will ultimately increase enough to off-set decreased snowfall and cause a decrease in soil frost depth; and
    - More variable winter weather causing an increase in the number of freeze/thaw cycles per year, resulting in increased root damage of frost-intolerant tree species and affecting the timing of nutrient release in forest soils; northern hardwood species (like sugar maple) are most likely to be negatively affected by this kind of root damage (Handler et al., In Press).
- Growing Season and Productivity
    - Longer growing season and warmer temps will result in increases in productivity for deciduous forest types (Handler et al., In Press) as long as there are enough water and nutrients available (Swanston, 2011); and
    - Likely a general increase in forest productivity in northern Lower Peninsula, but could be affected by CO2 fertilization effects and likely limited by moisture availability (Handler et al., In Press).
- Species and Habitat
    - Increased temperatures causing increased deer populations, resulting in increased herbivory and/or competitive advantage for those species not eaten (Handler et al., In Press);
    - Changes in multiple climatic factors causing drying of ephemeral ponds, resulting in increased stress on dependent species (Swanston, 2011); and
    - Changes in multiple climatic factors causing changes in hydrology of lowland systems, resulting in increased stress on dependent species (Handler et al., In Press).

Potential Combined Impacts:

- Increased invasive species and pest stress exacerbating existing stress complexes, including current land use activities (Vose et al., 2012);
- Increased drought exacerbating existing stress complexes, resulting in higher tree mortality, slow regeneration in some species and altered species assemblages (Vose et al., 2012);
- Decreased snow cover, causing even more reduced soil moisture, resulting in decreased tree vigor and increased forest susceptibility to insects and pathogens that will likely be increased due to climatic factors alone (Vose et al., 2012);
- Increased disturbance causing even greater fragmentation in landscapes that are already highly fragmented, resulting in even more decreased habitat connectivity and corridors for species movement (Vose et al., 2012);
- Decreased moisture and increased temperatures causing weakened trees (from moisture and heat stress), resulting in even greater damage from pests and diseases; examples include hypoxylon canker, forest tent caterpillar, gypsy moth, oak wilt and oak decline (Handler et al., In Press);

- Earthworm activity causing forest stands to have increased susceptibility to drought, resulting in drought-stressed trees that are even more susceptible to pests and disease that will likely be increased due to climatic factors alone (Handler et al., In Press); and
- Increased pests and diseases and increased extreme weather events causing increased mortality, resulting in increased fuel loads and even greater wildfire risk that will likely be heightened due to climatic changes alone (Handler et al., In Press).

The ability of a forest community to cope with potential impacts will also be affected by many additional factors. For example, communities with greater species diversity and structural complexity and those that are more tolerant of disturbance will tend to be better able to adapt to climatic changes. Whereas, forest communities within highly fragmented landscapes or that are very limited to certain spatial areas due to specific abiotic requirements will tend to be less able to adapt. The "*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis"* (Handler et al., In Press) includes a much more detailed assessment of northern Lower Peninsula forest type adaptive capacity.

Potential Impacts to Forest Management Activities (Handler et al., In Press)

- Increased occurrence of intense precipitation events causing increased soil erosion and potential effects on forest infrastructure, affecting access to forests for management activities; roads and bridges are of particular concern;
- Increased disturbance events causing increased tree mortality, resulting in increased salvage cuts;
- Changes to and greater variability in winter weather (increased freeze/thaw cycles, increased air temps, increased rainfall, fewer days of soil frost in the long-term, less snow to protect soils), resulting in more limited access to stands for management activities and increased soil erosion and sedimentation from use by trucks; and
- Decreased soil moisture (particularly later in the growing season and during prolonged droughts), resulting in increased access to stands in typically wetter areas for management activities in summer.

Key Vulnerabilities [to the Forestry Sector] across the Midwest Region (Handler et al., 2012)

- Climate change will amplify many **existing stressors** to forest ecosystems, such as invasive species, insect pests and pathogens and disturbance regimes (very likely);
- Climate change will result in **ecosystem shifts and conversions** (likely);
- Many tree species will have **insufficient migration** rates to keep pace with climate change (likely);
- Climate change will amplify existing stressors to **urban forests** (very likely);
- Forests will be less able to provide a consistent supply of some **forest products** (likely);
- Climate change impacts on forests will impair the ability of many forested watersheds to produce reliable supplies of **clean water** (possible);
- Climate change will result in a widespread decline in **carbon storage** in forest ecosystems across the region (very unlikely);
- Many contemporary and iconic forms of **recreation** within forest ecosystems will change in extent and timing due to climate change (very likely); and
- Climate change will alter many traditional and modern **cultural connections** to forest ecosystems (likely).

Differences that May Affect northern Lower Peninsula Forest Community Response to Climate Change

- This region has more fragmentation than some other regions of Michigan: Application of climate change adaptation strategies across landscapes may be more difficult; Migration may be more difficult for species;
- This region has more lake-effect areas than some other regions of Michigan and significant climatic differences between lakeshore and inland areas: Communities with specific climate requirements, such as lake-effect areas, may be highly vulnerable to climatic changes; lake-effect areas may be especially vulnerable due to dependency on complex relationships including lake water temperature, lake water level, air temperature and precipitation; climatic differences in the region make it more difficult to model/predict climatic changes and impacts;
- This region has more areas with deep, sandy soils than other regions in Michigan: Forest communities in these areas tend to be more drought-tolerant and may be better able to adapt to climatic changes and resulting impacts; forest communities in these areas tend to be fire-adapted and may be better able to adapt to climatic changes and resulting impacts; forest communities may be at increased risk for structural and functional changes, including conversion to barrens or grasslands, due to even higher risk of wildfire;

- This region is more reliant on and has greater capacity for planting to regenerate forest communities than some other regions of Michigan: More opportunities for assisted migration may occur; species may experience greater stress from climatic changes that affect regeneration and add to existing stress complexes;
- This region has more oak and jack pine forest communities than other regions of Michigan: The kinds of communities are more adapted to disturbance than other types and may be better able to adapt to climatic changes and resulting impacts; oak and jack pine are likely more vulnerable to climate change than many other forest species;
- This region has fewer potential ‘reference areas’ or ‘refugia’ than other regions of Michigan: Areas that provide safe harbor for vulnerable species and communities will likely be less prevalent on the landscape;
- This region has less connectivity to the north than some other regions of Michigan: A shifting northern Lower Peninsula/southern Lower Peninsula tension zone will likely reduce the regional area and limit opportunities for species and communities to adapt to climatic changes and migrate to new areas;
- This region has a higher wildfire risk than other regions of Michigan: Migration may be more difficult for species due to greater potential for increased fragmentation; forest communities may be at greater risk for structural and functional changes, including conversion to barrens or grasslands; many existing forest communities are already adapted to wildfire;
- This region has greater exposure to species invasions and new migrants (through the southern Lower Peninsula) than some other regions of Michigan: New invasive species and competition from new migrants may exacerbate existing stresses and increase forest community vulnerability to climatic changes; and
- This region has greater potential for agricultural expansion into forest lands than other regions in Michigan: Forest community vulnerability to climatic changes may increase due to additive stresses from land use changes and increased introduction of new invasive species and new stress complexes.

Summaries of “Winners” and “Losers”

The “*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis*” (Handler et al., In Press) used the Tree Atlas and LANDIS-II models to predict future trends in tree species for the northern Lower Peninsula. Detailed information about the models, differences between the models and model results are available in the publication. ‘Declining’ and ‘increasing’ refers to the overall existence of the species in Michigan forests and may include spatial changes in suitable habitat availability, productivity, general health of the species or some combination of these outcomes. It is important to note that the models do not account for all factors that may influence tree species and forest communities under a changing climate, including forest management – such as whether artificial regeneration is employed.

RESULTS CONSISTENT BETWEEN MODELS		RESULTS INCONSISTENT BETWEEN MODELS	
Declining Overall, with Greater Declines Under Higher Emission Scenario		**More Declining than Increasing**	
Balsam fir	Jack pine	Eastern hemlock	Red pine
Balsam poplar	Northern white-cedar	Quaking aspen	Yellow birch
Black ash	Paper birch	Red maple	
Black spruce	White spruce		
Eastern hemlock			
Stable or Increasing Under Lower Emission Scenario, Declining Under Higher Emission Scenario		**Really Mixed Results**	
American beech	Eastern white pine	American basswood	Northern pin oak
Big-tooth aspen	Northern red oak	Black oak	Sugar maple
Black cherry	Red maple	Green ash	
Increasing Under Both Emission Scenarios		**More Increasing than Declining**	
American elm	White ash	White oak	

The “*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis*” (Handler et al., In Press) used modeling results, literature review and expert opinion to assess potential impacts and ability to adapt to climatic changes for forest communities northern Lower Peninsula and develop overall assessments of vulnerability to climate change for those forest communities. Detailed information about the assessment and synthesis process, as well as results, are available in the publication.

VULNERABILITY	FOREST SYSTEM
High	**Upland spruce-fir**
High-Moderate	**Jack pine (including pine-oak)** **Lowland conifers** **Red pine-white pine**
Moderate	Aspen-birch Lowland-riparian hardwoods Northern hardwoods
Low-Moderate	Barrens Oak associations

3.3 – Region wide Forest Resource Base Conditions

The state forest in the northern Lower Peninsula covers roughly two million acres, representing approximately 19% of the 10.7 million acres of the ecoregion. Almost 87% of the state forest is forested, with 13% being non-forested (Table 3.1). Aspen represents the largest state forest cover type (24%); followed by northern hardwood, jack pine and oak at 10%; and red pine at 8% (Table 3.1 and Figure 3.1). Deciduous uplands comprise 47% of the forest; upland conifers 23%; lowland conifers 9% and lowland deciduous tree species comprise 7% of the forest land. Deciduous tree species (55%) and upland site conditions (70%) dominate the northern Lower Peninsula state forest area (Figure 3.2).

Approximately one-quarter (23%) of the state forest area is made up of late successional forest types; about a quarter (24%) is in mid-successional forest types; and the remainder (40%) is comprised of early successional types (Figure 3.3).

Timber sale records from 2002-2011 indicate that annual state forest timber sale acres in the northern Lower Peninsula ecoregion have been steady with minor fluctuations between 26,000 and 36,000 acres. Harvest acres of northern hardwoods, jack pine, oak and red pine have been steady with the exception of aspen acres which declined after 1997.

Table 3.1. Extent of current cover types for the northern Lower Peninsula ecoregion state forest land (2012 Department of Natural Resources inventory data).

Extent of Current Cover Types for the northern Lower Peninsula ecoregion.		
Current Operational Inventory Data, 2012		
Category/Cover Type	State Forest Land Area (Acres)	Percent of Total Area in Category
Aspen	496,754	24%
Northern Hardwood	215,204	10%
Jack Pine	207,084	10%
Oak	201,067	10%
Red Pine	167,896	8%
Lowland Deciduous	99,201	5%
Lowland Conifers	89,842	4%
Cedar	77,881	4%
Mixed Upland Deciduous	46,626	2%
Lowland Aspen-Balsam Poplar	41,957	2%
White Pine	40,088	2%
Natural Mixed Pines	26,209	1%
Upland Mixed Forest	21,014	1%
Lowland Mixed Forest	11,791	1%
Lowland Spruce-Fir	8,978	0%
Tamarack	7,882	0%
Upland Spruce-Fir	7,064	0%
Planted Mixed Pines	6,536	0%
Paper Birch	3,431	0%
Upland Conifer	2,791	0%
Hemlock	1,456	0%
Lowland Open/Semi-Open Lands	138,187	7%
Upland Open/Semi-Open Lands	104,070	5%
Other (Water, Local, Urban)	27,174	1%
Total State Forest Area	**2,050,183**	**100%**
Forested Total	**1,780,752**	**87%**
Non-Forest Total	**269,431**	**13%**

Aspen

Aspen forest cover types make up approximately 24% of the state forest lands in the northern Lower Peninsula (Table 3.1) and occupy a wide range of sites. This cover type is comprised of nine species associations which contain the following tree species: trembling and big tooth aspen, white birch, oak, northern white cedar, white spruce, balsam fir and jack pine. Aspen species are dominant in each of the nine associations which are further defined by the presence of one or more of the other associated species. Historically aspen was a minor associate tree species in several natural communities (primarily mesic northern forest, dry-mesic northern forest and dry northern forest), but was also found as a component of other communities. The occurrence of aspen was usually due to some a stand replacing disturbance. The intensive logging associated with European settlement greatly expanded the occurrence of the aspen forest type from pre-European settlement times and it is now generally managed to ensure its presence is maintained on the landscape.

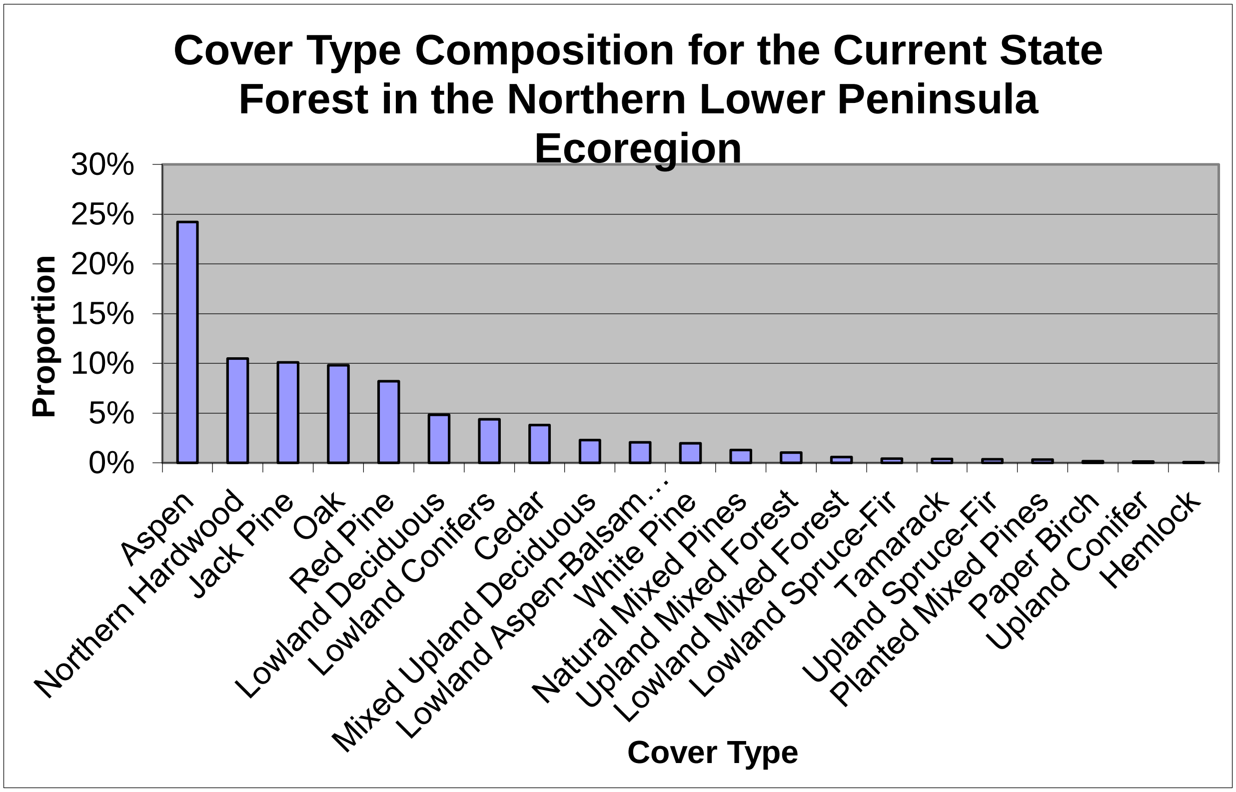

Figure 3.1. Cover type composition for the current state forest in the northern Lower Peninsula ecoregion (2012 Department of Natural Resources inventory data).

Aspen is an early successional forest type that provides habitat for species such as white-tailed deer, ruffed grouse, woodcock, snowshoe hare, beaver and golden-winged warbler. Large (>18 inches in diameter at breast height) mature and over-mature aspen are preferred cavity trees for pileated woodpeckers.

Wildlife habitat management techniques in the aspen cover types include retaining mesic conifers; retaining and recruiting standing and down dead wood; protecting raptor nest trees and wildlife den trees; and providing multiple –age classes across the landscape of the state forest system.

Aspen in the northern Lower Peninsula ecoregion has been intensely managed for wood products and habitat since the 1970s and as a result, much of the aspen is in younger age classes. As the overall aspen resource matures, harvesting will increase with the goal of balancing age classes.

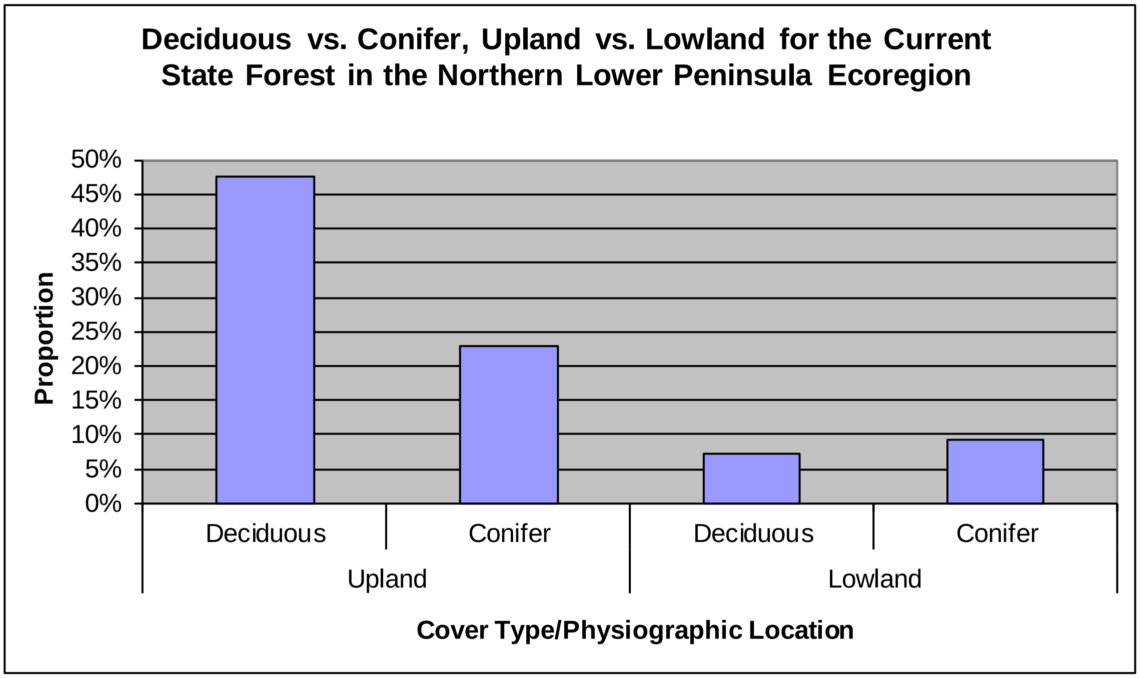

Figure 3.2. Upland and lowland cover types in the state forest in the northern Lower Peninsula ecoregion (2012 Department of Natural Resources inventory data).

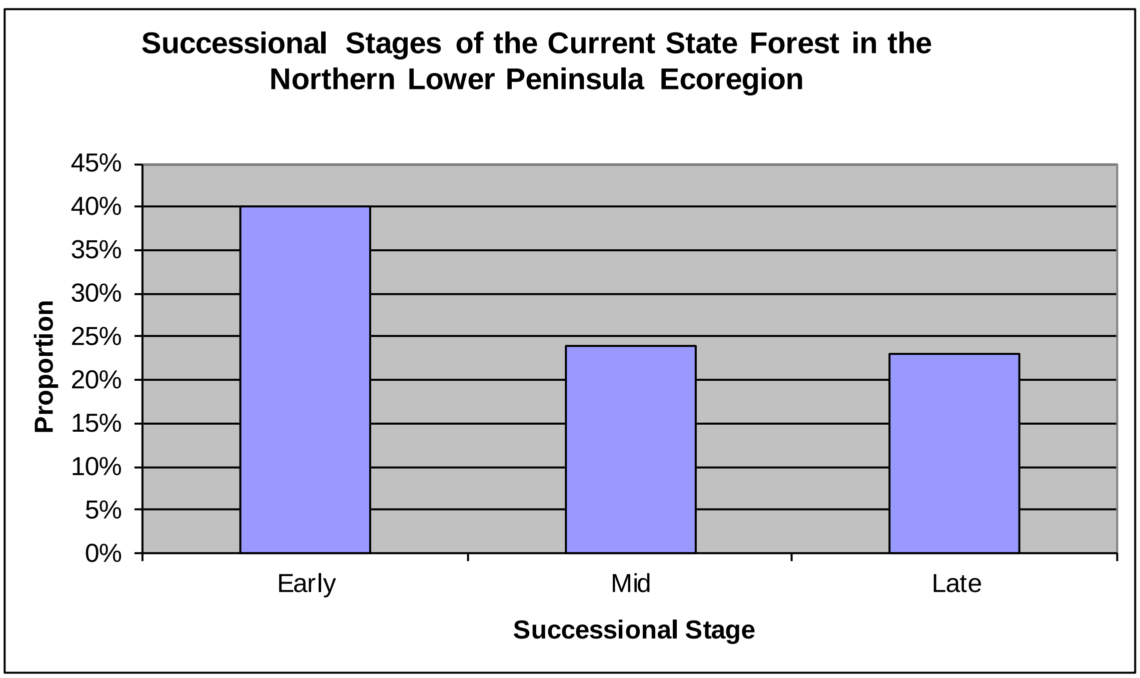

Figure 3.3. Successional stages for the state forest in the northern Lower Peninsula ecoregion (2012 Department of Natural Resources inventory data)

The "*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis*" (Handler et al., In Press) for the northern Lower Peninsula summarized potential impacts, vulnerabilities and ability to adapt to projected future climate changes for tree species and forest types. Both species of aspen (trembling and big-tooth) are predicted to decline, particularly under a higher emission future. Overall, the aspen forest type is adapted to disturbance events and exists on a wide range of sites, which could improve its ability to adapt to climatic changes and resulting impacts. However, it has a low species diversity, which may limit options for future trajectories and reduce its ability to adapt to climatic changes. Drought and forest pests are of significant concern for aspen species – both of which are expected to increase over time.

Northern Hardwoods

Northern hardwoods account for approximately 10% of the total state forest habitat in the northern Lower Peninsula (Table 3.1). This forest cover type is comprised of nine species associations, including sugar maple, American beech, basswood, white ash, cherry, northern red oak, yellow birch, trembling and big-tooth aspen, red maple, hemlock, white pine and white spruce. Sugar maple, beech, yellow birch, red maple or mixtures of these species tend to be dominant. Northern hardwoods are synonymous with two natural communities in the northern Lower Peninsula: mesic northern forest and southern mesic forest.

Northern hardwoods represent a late successional stage (Figure 3.3) of forest development and provide habitat for approximately 113 wildlife species. Large contiguous blocks of northern hardwood forest provide important habitat for area-sensitive and interior species such as ovenbird, American marten, red-shouldered hawk (state threatened), northern goshawk (state special concern), black-throated blue warbler, wood thrush and black bear. The state land ownership pattern in the northern Lower Peninsula results in a fragmented pattern in the northern hardwood cover type making it difficult to manage for large contiguous blocks over much of the landscape. Several plants and animals of concern occur in these communities including walking fern (state threatened); Hart's-tongue fern (state endangered); goblin moonwort (state threatened); and fairy bells (state endangered). This cover type also provides an important habitat component for pileated woodpecker (a featured species).

Salvage of ash and American beech in northern hardwoods in response to emerald ash borer and beech bark disease has changed the normal harvest entry pattern. This may result in fewer areas being available for harvest during this 10-year period and perhaps extending further.

The "*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis*" (Handler et al., In Press) for the northern Lower Peninsula summarized potential impacts, vulnerabilities and ability to adapt to projected future climate changes for tree species and forest types. This forest type has diverse tree species and can exist on a range of soil types and landforms, so there are many potential future trajectories, although they may include a different mix of species than is currently characteristic for northern hardwoods. Sugar maple is currently a key tree species in Michigan's northern hardwoods – unfortunately, model results have been mixed for this species and it is difficult to predict any future trends at this time. This species is shade tolerant and has fewer disease and insect pests relative to other species, so it may be able to adapt to climatic changes and continue to persist in many areas where it currently exists. However, sugar maple is also often limited to soils rich in nutrients like calcium, which may limit its future habitat opportunities. Overall, the northern hardwoods type is less adapted to widespread, more frequent disturbance events than others, which could limit its ability to adapt to climatic changes and resulting impacts. It is intolerant of frequent soil freeze/thaw cycles, which are predicted to increase. It could also potentially lose the ephemeral pond component of the ecosystem. Northern hardwoods may not do as well where it occurs in simplified stands with low species diversity.

Oak

The oak forest cover type contains several species of oak (red, white, black or northern pin) and covers approximately 10% of the state forest lands (Table 3.1). There are eight different groups of species associations in the oak cover type. Associations can be mixtures of oak species, which may also include hickory, white, red and jack pine or aspen species.

Historically oak was a minor associate tree species in several natural communities (primarily mesic northern forest, dry-mesic northern forest and dry northern forest), but was also present in several natural savanna communities including oak-pine barrens and pine barrens and was also found as a component of other communities. The historical occurrence of oak was usually due to moderate- to large-scale wind or fire disturbance. The intensive logging associated with European settlement greatly expanded the occurrence of the oak forest type from pre-European settlement times and it is now a dominant or associate tree species in the dry-mesic northern forest and dry northern forest natural communities.

Oak is very important to healthy populations of many wildlife species and particularly popular forest game species in the ecoregion (black bear, elk, white-tailed deer, wild turkey and ruffed grouse). There are 39 vertebrate species of greatest conservation need associated with the oak cover type. Endangered, threatened or species of special concern include the black rat snake, eastern massasauga rattlesnake, eastern box turtle, bald eagle, northern goshawk, red-shouldered hawk, merlin, cerulean warbler, gray wolf, Indiana bat, eastern pipistrelle and woodland vole. Refer to Michigan Natural Features Inventory Community Abstracts and Wildlife Action Plan for more complete lists of special concern species.

On state forest lands, the oak type is nearing its biological life span and is gradually succeeding to other forest types and mixed oak-pine stands. Resource managers are working to balance the need to harvest older oak retaining older oak for the mast, knowing that without management it will otherwise eventually die and succeed to other types. Developing the capability to consistently regenerate oak is critical to maintaining the oak cover type on the landscape as mixed oak-pine stands as well as maintaining oak as a minor species in other types.

The oak resource is critical for wildlife and although the age-class distribution for oak is heavily skewed towards the older age-classes, harvest has been relatively consistent between the years of 1994-2004. The general trend for oak is toward mixed stands with jack, red and white pine along with other species. Young oak frequently grows below these pine species and may be released when the overstory pine is removed.

The "*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis*" (Handler et al., In Press) for the northern Lower Peninsula summarized potential impacts, vulnerabilities and ability to adapt to projected future climate changes for tree species and forest types. White oak may do better under a lower emission future climate, but will likely have fewer advantages under hotter, drier conditions of a higher emission future climate. Red oak predictions are mixed under lower emission future climates, but predict a decline under higher emission future climates. Model results have been mixed for black oak and northern pin oak, making it difficult to predict any future trends at this time. Oaks are limited by cold temperatures and may be able to expand in distribution with predicted temperature increases. Unfortunately, due to limited distribution in the eastern Upper Peninsula and barriers to natural migration in the northern Lower Peninsula , this expansion may not be extensive. There are already some issues with regeneration of oak and changes, including decreased soil moisture could amplify these stresses. Oak is generally adapted to periodic drought and warmer temperatures and can exist on a range of soils, which may make it overall better able to adapt to future climatic changes and resulting impacts. In general, oak-associations have high species and genetic diversity which will provide them with many potential future trajectories (especially in the northern Lower Peninsula) and may help them to better adapt to future climatic changes. There is a potential for increased impacts and novel stress complexes from increases in pests, diseases, invasive species and deer herbivory.

Upland Conifers

This broad category includes mixes of hemlock, spruce-fir, jack pine, red pine and white pine forest types. Approximately 23% of the forested habitats on the state forest are in these types. Natural communities include mesic northern forest, dry-mesic northern forest, dry northern forest, boreal forest and hardwood-conifer swamp. On a regional basis, most of the mesic conifer (about 60%) and half of the dry conifer forests are considered to be in fair to good condition (Michigan's Wildlife Action Plan 2005 http://www.michigan.gov/dnr/0,4570,7-153-10370_30909-236396--,00.html).

Eastern Hemlock

Eastern hemlock is a dominant species in less than 1% of the forested landscape of the northern Lower Peninsula state forest land (Table 3.1). Hemlock is more commonly a minor component of several other forest cover types. Natural communities that have a minor component of hemlock include mesic northern forest, dry-mesic northern forest and hardwood-conifer swamp. Mesic conifer natural communities are considered rare or uncommon (Michigan's Wildlife Action Plan, 2005). The conditions required to successfully regenerate hemlock are not occurring naturally and silvicultural treatments aimed at hemlock regeneration have had limited success. This trend is expected to continue for the foreseeable future.

Wildlife habitat management techniques for hemlock include leaving all hemlock within northern hardwood stands, under-planting hemlock where suitable, expanding existing stands (where possible) by regenerating hemlock along the drip line of stand boundaries and retaining canopy closure of at least 80 percent to retain their snow intercept value. Retaining standing and down dead wood, retaining raptor nest- and den-trees and retaining representation of all vegetative species (vertical structure) is highly desired within ecosystems that contain hemlock.

Hemlock is a very important component of old growth and is also a major component of late successional forest types. A total of 44 species of special concern are associated with mesic conifers in the northern Lower Peninsula ecoregion.

There has been very little timber harvesting activity in hemlock forests over the past decade, and no appreciable change is expected due to the relatively limited acreage of this cover type in the northern Lower Peninsula ecoregion.

The "*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis*" (Handler et al., In Press) for the northern Lower Peninsula summarized potential impacts, vulnerabilities and ability to adapt to projected future climate changes for tree species and forest types. Eastern hemlock is generally predicted to decline, especially under higher emission future climates. The species may have a physiological 'tipping point' beyond which it is unable to compete and survive. This species is drought intolerant and is threatened by the hemlock wooly adelgid, both of which are predicted to increase, and will likely decrease eastern hemlock's ability to adapt to future climatic changes and resulting impacts. It occurs at low density across the landscape and is already in decline in some areas. The lowland conifer forest type has a limited tolerance for changes in water table making it more vulnerable to climatic change. Eastern hemlock is a key species in this forest type. Overall, the spruce-fir forest type, of which eastern hemlock is also a key species, is predicted to have a weaker potential productivity response to predicted climatic changes (warmer temperatures and longer growing seasons) than other forest types.

White Pine

The white pine forest cover type comprises only 2.0% of state forest land in the northern Lower Peninsula ecoregion, but white pine is also a minor component in several other cover types. White pine is found in several natural communities including boreal forest, dry-mesic northern forest, dry northern forest, mesic northern forest, hardwood-conifer swamp, wooded dune and swale complex, poor conifer swamp, rich conifer swamp, rich tamarack swamp, pine barrens and Great Lakes barrens. Several plants and animals of special concern occur in these communities including, purple clematis (state threatened), Canada rice-grass (state threatened), pine drops (state threatened), bald eagle (special concern) and merlin (state threatened).

As a result of extensive harvesting during the 19th century lumbering era, the dominance of white pine has been greatly reduced in the present landscape, but it is a major component in the understory and emerging into the overstory of many oak stands and is gradually becoming more dominant in this and other forest types. White pine is a very important component of old growth and is also a major component of late successional forest types.

Wildlife habitat management techniques include retaining super-canopy white pine trees within stands, restoring white pine as a component of northern hardwood stands, retaining and enhancing standing and downed dead white pine wood, retaining white pine nest trees and den trees and managing for a diverse suite of tree and herbaceous species in ecosystems containing white pine.

There has been relatively very little timber harvesting activity in white pine forests over the past decade, but this can be expected to gradually increase as the acreage of white pine expands in the northern Lower Peninsula ecoregion.

Jack Pine

The jack pine forest cover type comprises about 10% of the state forest land (Table 3.1) on both upland and lowland sites. Jack pine stands can be of natural or planted origin and can be found with deciduous species or as a minor component with aspen. It is associated with other tree species in several natural communities, including inter-dune wetland, poor conifer swamp, boreal forest, dry northern forest, oak-pine barrens, pine barrens and Great Lakes barrens.

Several plants and animals of special concern occur in these communities in the northern Lower Peninsula ecoregion including Canada rice grass (pine barrens - state threatened), Kirtland's warbler (federally endangered and state endangered) and prairie warbler (young jack pine stands - state endangered).

Wildlife habitat management techniques include managing jack pine in larger stand sizes (at least 100 acres), variable retention of red pine and white pine at low densities within and along the edges of jack pine stands, the retention of snags and large woody debris.

Jack pine harvest has also remained steady at a fairly high level in part due to accelerated harvests to avoid losing over-mature jack pine to budworm and for Kirtland's warbler habitat (which requires more acres in younger age-classes). This has resulted in age-classes that are skewed towards 0-9 and 10-19 years of age. It is expected that jack pine harvests may significantly decrease due to the younger jack pine age-class structure.

The "*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis*" (Handler et al., In Press) for the northern Lower Peninsula summarized potential impacts, vulnerabilities and ability to adapt to projected future climate changes for tree species and forest types. Jack pine is predicted to decline under all future emission climate scenarios. In northern Wisconsin, a decline in abundance is predicted, even though there may be some expansion of spatial distribution (limited by soils). The jack pine forest type has a low species diversity which may limit options for future trajectories and could potentially limit the ability of this forest type to adapt to climatic changes and resulting impacts. However, it is also disturbance adapted and could expand with increased widespread disturbance or it could convert to barrens, if disturbance is too great. Jack pine may face increased competition from hardwoods and greater pest and disease threats and may also be physiologically limited by increased temperatures.

Red Pine

As a result of extensive harvesting during the 19th century lumbering era, the dominance of red pine has been greatly reduced in the present landscape. Most of the red pine cover type on state forest lands in the northern Lower Peninsula ecoregion is a product of the intensive planting programs by the Civilian Conservation Corps and the state of Michigan from the period of the 1930s through the 1950s, and comprises approximately 8% of the area (Figure 2). Red pine is a dominant or associate tree species in several natural communities including boreal forest, dry-mesic northern forest, dry northern forest, pine barrens and Great Lakes barrens. Red pine stands (particularly those of natural fire origin) have the potential to have barren and prairie remnants. Representative plant species that are abundant in high-quality barren and prairie remnants include big and little bluestem grasses, pale *agoseris*, rough fescue, Hill's thistle, Canada rice grass (state threatened) and Alleghany plum.

Wildlife habitat management techniques for red pine include the use of prescribed fire for regeneration, variable retention of pine and other species within stands, retaining nest and den trees and retaining and restoring snags and large woody debris in pine forests.

The age-class structure of red pine has been skewed with most of the resource between sixty and eighty years of age, correlating with earlier intensive planting programs by the Civilian Conservation Corps and the state of Michigan. The DNR recommends increasing stand replacing harvests of this older pine to achieve a more balanced red pine age-class distribution.

The "*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis*" (Handler et al., In Press) for the northern Lower Peninsula summarized potential impacts, vulnerabilities and ability to adapt to projected future climate changes for tree species and forest types. Red pine is predicted to decline under all future climate scenarios and may be physiologically limited by increased temperatures. Of particular concern are pest and disease threats, as well as novel interactions between stresses. The red pine-white pine forest type has a low species diversity which may limit future trajectories. However, it is adapted to drought and disturbance, which may increase its ability to adapt to climatic changes. This forest type is wildfire adapted and could expand with increased occurrence of wildfire or it could convert to barrens with too much wildfire. Dependence on planting for regeneration of red pine could be a limiting factor, as planting and regeneration success may be highly affected by a predicted shift to wetter springs and drier summers.

Lowland Coniferous Forest

This broad category includes lowland cedar, black spruce, lowland fir and lowland pine forest cover types and comprises approximately 4% of the state forest area in the northern Lower Peninsula ecoregion (Table 3.1). Some lowland conifer natural communities (hardwood-conifer swamp, muskeg, rich conifer swamp, rich tamarack swamp and wooded dune and swale complex) are classified as rare or uncommon in the state (Michigan's Wildlife Action Plan, 2005). These lowland coniferous forests are very important to wildlife values in the northern Lower Peninsula. Current threats to lowland coniferous forests include: altered fire and hydrologic regimes, fragmentation, forest conversion, consumptive forestry practices, non-consumptive recreation and biological interactions such as herbivory of regeneration. Timber harvesting activity in lowland conifer forests over the past decade has been limited. However, increased management is expected where desirable outcomes can be achieved.

The "*Michigan Forest Ecosystem Vulnerability Assessment and Synthesis*" (Handler et al., In Press) for the northern Lower Peninsula summarized potential impacts, vulnerabilities and ability to adapt to projected future climate changes. Northern white cedar is a key species in lowland coniferous forests and is predicted to decline under all future emission scenarios. Increases in pests and deer herbivory are of particular concern. The lowland coniferous forest type has a limited tolerance for changes in water table, which may make it more vulnerable to climatic changes. It is also closely associated with sphagnum moss, which will likely be limited by future increases in temperature.

Upland Open/Semi-Open Habitat

Upland herbaceous open land habitat is an important vegetation type with over 100 vertebrate animal species and over 50 rare plant species use the various open land ecosystems in the northern Lower Peninsula ecoregion (Michigan Department of Natural Resources et. al, 2000). Threats to these open-land communities continue due to altered fire regimes, land fragmentation, habitat conversion, mineral development, non-consumptive recreation, invasive plant species and ungulate foraging (Michigan's Wildlife Action Plan, 2005).

Species of concern occurring in herbaceous open-land communities include sharp-tailed grouse (special concern), prairie birdfoot violet (state threatened) and Hill's thistle (special concern). These areas are used for feeding by merlin (state threatened) and Kirtland's warbler (federal and state endangered).

Wildlife habitat management techniques used to manage this habitat type include maintaining the structure and function of historic open lands, promoting prescribed fire to restore and maintain native plant and animal communities and the control of exotic invasive plant species. One of the challenges facing managers is in determining where openings should be maintained or created to meet specific management objectives.

Upland Open/Semi-Open Habitat

Upland shrub habitat is dominated by sweet fern, blueberry and various upland shrubs and has coniferous, deciduous or both types of trees with less than 25% canopy closure. These areas are often spatially and temporally dynamic across the landscape since they are an intermediate successional stage between herbaceous vegetation and early successional forest. This habitat type is maintained by fire or hand felling of woody encroachment, frost induced mortality of encroaching woody vegetation and occasionally cervid herbivory. Open habitat created through timber harvests may be slow to naturally regenerate, especially on poor quality soils and upland open/semi-open habitat may persist for many years before converting to a more forested condition. Young regenerating pine, where pine canopy covers less than 25% of the area, are also classified in this category. Although there are no defined native natural communities associated with this habitat type, it is often similar to oak-pine barrens.

Wildlife habitat management considerations include maintaining the structure and function of historic open lands; the establishment of various size blocks of temporary openings or clearcuts when harvesting pine or oak; determining where openings should be maintained or created to meet specific management objectives; determining where openings that historically supported forest vegetation will be allowed to succeed to a forested condition; promoting prescribed fire to restore and maintain native plant and animal communities; and the control of exotic invasive plant species.

Lowland Open/Semi-Open Habitat

Lowland open/semi-open habitat type includes bog, treed bog, fen and shrub-carr vegetation types. Communities associated with lowland shrub include: bog, intermittent wetland, muskeg, northern fen, patterned fen, poor fen, northern shrub thicket and northern wet meadow. Much of this habitat type is in state and federal ownership being acquired through tax reversion (as has most public lands), and is recognized as a unique habitat.

Wildlife habitat management techniques include the restoration and maintenance of natural wetland hydrology, restoration of wetlands on private lands through state and federal grants, limiting fragmentation of large wetland complexes, minimizing intrusive activities, controlling invasive plant species, buffering management activities adjacent to wetlands and the maintenance of wildlife floodings for the restoration and management of wild birds and mammals and their associated recreation values.

Marsh and Bog Habitats

Mixed wetland habitat, including marsh and bog, are extensive in the northern Lower Peninsula and represent an important wildlife habitat type. Associated natural communities may include interdunal wetland, intermittent wetland, Great Lakes marsh, bog, muskeg, patterned fen, poor fen, northern fen and northern wet meadow. Species of concern using this habitat type include yellow rail (state threatened), northern harrier (special concern) and dwarf raspberry (state endangered).

Wildlife techniques for habitat management include the maintenance and restoration of natural hydrology, minimizing intrusive activities, controlling invasive plant species and buffering management activities adjacent to wetlands.

Restrictions on Timber Harvesting

Any discussion of forest cover types and the availability of timber for harvest must consider that basis of forest land that is actually suitable for timber production. There are five categories of state forest acres which are mostly unavailable for timber harvests:

- Forest land that is leased to other governmental agencies or private corporations for other uses;
- Non-forested lands (bogs, grasslands, sand dunes, water, etc.);
- Forest land that is withdrawn from timber production (with a legal basis) for ecological purposes (high conservation value areas and ecological reference areas);
- Forest land that is not physically suited for timber production (many lowland forests and physically inaccessible lands); and
- Forest land that is not appropriate for timber production (administratively removed lands that are used for other purposes, such as roads and campgrounds or as old growth).

These categories can overlap each other on any given acre of the state forest, so this analysis accounts for overlap to provide an accurate estimate of forest land that is suitable for timber production. This analysis also accounts for many factors that constrain or limit the prescription of stands that meet a silvicultural criterion and are otherwise ready for harvest. Treatment limiting factors are used to record constraints on the availability of a stand for harvest. There currently are five categories of limiting factors (Appendix C): (1) Administrative and legal factors; (2) Accessibility factors; (3) Special management or use designation; (4) Markets and industrial factors; and (5) Technological/ecological factors. These limiting factors are used to identify reasons that harvest cannot occur.

The accounting framework for a current estimate of state forest land that is suitable for timber production starts with the approximately 2,050,000 acres of state forest in the northern Lower Peninsula ecoregion (Table 3.2). Of this total there are 112,082 acres that are leased to the Department of Military Affairs for Camp Grayling and for oil and gas production. An additional 258,878 acres are non-forested, which include rock, water, marshes, grass and brush lands. These lands provide wildlife habitat and are important recreational and biological components of the landscape; but, they are not part of a working timber base. After accounting for leased and non-forested lands, the estimate of actual forest land in the northern Lower Peninsula ecoregion is about 1,679,000 acres (Table 3.2).

Lands that are withdrawn from timber production for ecological purposes (high conservation value areas, and ecological reference areas) total 9,320 acres of state forest in the northern Lower Peninsula ecoregion. Lands which are not physically suited for timber production (due to wetness, with water quality concerns, physical inaccessibility or steep slopes) total 65,395 acres. After accounting for these two categories, there are an estimated 1,604,000 acres of state forest land that is tentatively suitable for timber production (Table 3.2).

There are 84,191 acres of lands that have been administratively removed from timber production for other purposes and uses (including recreational uses, non-dedicated natural areas, Type 1 and 2 old growth, deer winter habitat and forest roads). Accounting for these areas yields an estimated 1,520,000 acres of state forest land that is suitable for timber production in the northern Lower Peninsula ecoregion (Table 3.2).

This analysis does not account for temporary treatment limiting factors that can also constrain or limit the prescription of stands that meet a silvicultural criterion and are otherwise ready for harvest. Stands with temporary limiting factors will be harvested once the factors have been satisfied (longer rotation age) or are eliminated (need for a bridge).

Table 3.2 State forest lands suitable for timber production for the northern Lower Peninsula ecoregion. (2013 Department of Natural Resources inventory data)

Major Categories	Acres[1]	Acres	Definitions
		2,049,565	**Total DNR State Forest Land**
Leased Lands	-112,082		This category includes lands that are leased to the Department of Military Affairs, Luce County, and to corporations for mineral, oil and gas extraction facilities.
Non-forest Land	-258,878		This category is comprised of non-stocked acres: bogs, muskeg, grasslands, rock, lowland and upland brush, marsh, sand dunes, and water.
		1,678,605	**= Forest Land**
Forest Land Withdrawn from Timber Production	-9,320		This category is comprised of areas that are legally or otherwise dedicated to other uses that preclude timber production: Dedicated Natural Areas, Natural River Buffers, Ecological Reference Areas, Critical Dunes, Designated Critical Habitat (Piping Plover), and Coastal Environmental Areas.
Forest Land not Physically Suited for Timber Production	-65,395		This category is comprised of areas that have site conditions where timber production would cause resource damage to soils, productivity, or watershed conditions: being too steep (Code 2F), too wet (Code 2G), blocked by physical obstacle (Code 2H), Influence Zones (Code 3G), and water quality/BMPs (Code 3J).
		1,603,890	**= Forest Land Tentatively Suitable for Timber Production**
Forest Land not Appropriate for Timber Production	-84,191		This category is comprised of areas that are administratively removed for other resource values and management uses: Recreation Areas (SF Campgrounds, Motorized Trails, and Scramble Areas), Scenic Values (Code 3D), Proposed and Nominated Natural Areas, Possible and Verified Type 1 and 2 Old Growth Areas, Potential Old Growth (Code 3A), Deer Wintering Areas (Code 3H), TE&SC Species (Code 3B), other wildlife concerns (Code 3L), Archeological Sites (Code 3I), Rare Landforms (Code 3K), Non-Military Easements (Code 3E), Forest Roads, and Other Administrative/Legal Factors (Codes 1A, 1B, 1C, and 1D).
		1,519,699	**= Forest Land Suitable for Timber Production**

[1] Acres have been adjusted to eliminate duplicate accounting where multiple designations occur for any given area. Absolute acres are higher for any given category.

3.4 Forest Health Conditions and Trends

The northern Lower Peninsula faces several major forest health concerns. The introduction of non-native plants, insects and diseases are a serious threat to the health and plant species composition of the state's forest ecosystems, although population cycles of endemic, native insects also cause periodic disturbance and can have a significant impact at a localized level.

Native insects and diseases periodically kill weakened and/or older trees. While outbreaks of some native insects and diseases periodically cause unacceptable growth loss and tree mortality, they also contribute to the process of forest regeneration, growth and renewal. Areas with large outbreaks, anticipated or on-going, often have timber harvest operations to salvage the usable fiber.

Unlike native insects and diseases, non-native species have not evolved with and are not integral parts of our forest ecosystems. These organisms cause new and sometimes devastating effects that disrupt natural functions and processes and have major consequences on the vegetative composition, structure, productivity and health of native forests.

Due to a continually emerging global economy, there is an ever-present threat of the introduction of new non-native invasive plants, insects and diseases. Recently introduced non-native species include the emerald ash borer, beech bark disease and the hemlock woolly adelgid. Introduced pests pose a major threat to U.S. forests, as well as those in Michigan. Some of these pests are transported inadvertently by movement of firewood, wood products and nursery stock. Quarantines and other types of restrictions try to curb the movement and introduction into other parts of the state and neighboring states.

The long-term ecological consequences of threats to forest health may not be fully apparent or immediately understood. To address this, Michigan participates in the national Forest Health Monitoring Program to evaluate the extent, severity and causes of changes in forest health. There is also ongoing research by various agencies, including the DNR.

A number of forest insects and diseases are present or may threaten forest conditions in the northern Lower Peninsula ecoregion (Table 3.3), the most significant of these being emerald ash borer, beech bark disease, oak wilt and hemlock woolly adelgid. All of these pests are present in Michigan now with the exception of hemlock woolly adelgid, which has been detected and eradicated in a few very isolated areas on ornamental trees. Table 3.4 shows the current incidence of forest pests by management area in the northern Lower Peninsula ecoregion. The most commonly found pathogens are oak decline, two-lined chestnut borer, *Armillaria* root rot, emerald ash borer and beech bark disease. The Grayling Outwash Plain management area has six pathogens present; there are six management areas with five pathogens; and three with four pathogens. Some of these pests pose a very serious threat and could eliminate the host tree species from Michigan's forested landscape. Currently there does not appear to be an effective treatment for any of these pests.

Table 3.3. Northern Lower Peninsula ecoregion forest pests, host species, origin, threat severity, incidence and trends.

Pest	**Host Species**	**Origin**	**Severity of Threat**	**Incidence In NLP**	**Trend**
Emerald Ash Borer	Ash	Non-Native	High/Extreme	Moderate - High, Extensive	Increasing
Beech Bark Disease	Beech	Non-Native	High/Extreme	Moderate-High, Extensive	Increasing
Forest Tent Caterpillar	Hardwoods	Native	Low	Low to Extensive	Periodic
Gypsy Moth	Oak and Aspen	Naturalized	Medium	Low to Extensive	Periodic
Oak Wilt	Oak (Red oak group)	Non-Native	High/Extreme	Low	Increasing
Oak Decline	Oak	Non-Native	High/Extreme	High	Increasing
Diplodia Shoot Blight	Red and Jack Pine	Native	Low	Low	Stable
Two-Lined Chestnut Borer	Hardwoods	Native	Low to High	Moderate-High	Increasing
Armillaria Root Rot	Hardwoods	Native	Low to High	Moderate-High	Increasing

Table 3.4. Presence of forest pests by management area for the northern Lower Peninsula ecoregion.

Management Area		Pest Occurrence Within a Management Area										
		Emerald Ash Borer	Beech Bark Disease	Forest Tent Caterpillar	Gypsy Moth	Oak Wilt	Oak Decline	Diplodial Shoot Blight	Two-Lined Chestnut Borer	Armillaria Root Rot	Pine Spittlebug	Total
MA-1	Great Lakes Islands											0
MA-2	Mackinaw Lake Plains						X		X	X		3
MA-3	Hammond Bay Lake Plains						X		X	X		3
MA-4	Emmet Moraines	X	X									2
MA-5	Cheboygan Lake Plain											0
MA-6	Cheboygan Basin Moraines	X	X				X					3
MA-7	Chandler Hills	X	X	X	X		X					5
MA-8	Pigeon River Country	X	X				X		X	X		5
MA-9	Jordan Valley	X	X									2
MA-10	Rattlesnake Hills	X	X				X		X	X		5
MA-11	Thunder Bay Outwash						X		X	X		3
MA-12	Alpena Lake											0
MA-13	Grayling Outwash	X	X				X		X	X	X	6
MA-14	Grayling Ice Contact	X	X				X		X	X		5
MA-15	Camp Grayling						X		X	X		3
MA-16	Avery Hills						X		X	X		3
MA-17	Kirtland's Warbler										X	1
MA-18	Benzie Moraines	X	X									2
MA-19	Williamsburg Moraine	X	X				X					3
MA-20	Benzie Outwash	X	X									2
MA-21	Boardman Plains					X	X		X	X		4
MA-22	Manistee Plains						X		X	X		3
MA-23	Manistee River Valley	X	X				X		X	X		5
MA-24	Houghton Lake Wetlands						X					1
MA-25	AuSable Outwash						X	X	X	X	X	5
MA-26	Wurtsmith						X		X	X		3
MA-27	Upper Muskegon						X		X	X		3
MA-28	Ogemaw Hills						X		X	X		3
MA-29	Lake County Outwash					X	X					2
MA-30	Lake County Moraines			X	X	X	X					4
MA-31	Evart Block					X	X	X				3
MA-32	Gladwin Lake Plain					X	X		X	X		4
MA-33 SLP MA-1	Midland-Isabella											0
	Total	12	12	2	2	5	24	2	33	33	3	

Invasive Plant Species

Invasive species are a serious threat to biodiversity and ecosystem function. Invasive species are those that are non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (National Invasive Species Council, 1999). Invasive species disrupt complex interactions among native species and hence ecosystem functions. Invasive species may displace native species, disrupt critical components of food chains (particularly invertebrates), be unpalatable or toxic, disrupt mutualistic relationships and/or diminish recreational opportunities (Higman and Campbell, 2009).

The potential threat of an invasive species is based on how fast it spreads, how quickly it will displace native vegetation and how difficult it is to control. There are several invasive species that present the highest threat to the state's forest systems that are not yet well established and for which local control and eradication is possible (Table 3.5). Tables 3.5 and 3.6 represent the best of our knowledge about invasive plant species; however, the database is incomplete – occurrences are more widespread than we know. These data can be supplemented by continuing to map the presence of invasive plant species as part of the compartment review process. This list, in conjunction with an early detection and rapid response system, will be used to help focus and prioritize prevention, monitoring and control activities.

Table 3.6 shows the presence of invasive plant species by management area and buffer zone for the management areas in the northern Lower Peninsula ecoregion. Glossy buckthorn is the most commonly found invasive plant in the northern Lower Peninsula management areas with 16 occurrences in four management areas. *Phragmites* represents the largest threat as there are 164 occurrences in 11 buffer areas. The Emmet Moraines management area has 19 occurrences of seven invasive species. Twenty-two management areas have no occurrences recorded.

Some eradication efforts have started on invasive species. Scots pine (*Pinus sylvestris*) is systematically being removed from state forest lands. Common (*Rhamnus cathartica*) and glossy buckthorn (*Rhamnus frangula)* plagues many areas of the state and are being removed as opportunities occur. Garlic mustard (*Alliaria petiolata*) monitoring, management and eradication projects are gaining momentum in Michigan; and public and private organizations are co-operating in efforts to remove and keep garlic mustard from establishing in new areas of the northern Lower Peninsula. Purple loosestrife (*Lythrum salicaria*) has been reduced to isolated areas by an introduced exotic leaf beetle (*Galareucella sp*.). There are also several other invasive plants of concern which have been detected. Invasive plant management is a new arena and training sessions for DNR personnel that include plant identification, reporting protocols and management strategies were conducted and will be repeated periodically.

Table 3.5. Non-established invasive species for northern Lower Peninsula ecoregion state forest lands.

Invasive species for the Northern Lower Peninsula ecoregion.				
Common Name	Scientific Name(s)	Wetland/Riparian	Forest Understory/Edge	Open/Grassland
Black and Pale Swallow-worts	*Cunanchum louiseae, syn. - Vincetaoxicum nigrum and C. rossicum, syn. - V. rossicum*	X	X	X
Common Buckthorn	*Rhamnus cathartica*		X	X
Garlic Mustard	*Alliaria petiolata*	X	X	X
Glossy Buckthorn	*Rhamnus frangula*	X	X	X
Japanese and Giant Knotweeds	*Fallopia japonica and F. sachalinensis*	X	X	X
Japanese Barberry	*Berberis thinbergii*		X	
Leafy Spurge	*Euphorbia esula*			X
Phragmites	*Phragmites australis*	X		
Oriental Bittersweet	*Celastrus orbiculatus*		X	
Narrow-leaf Cat-tail	*Typha angustifolia*	X		
Amur Honeysuckle	*Lonicera maackii*		X	X
Tartarian Honeysuckle	*Lonicera tatarica*		X	X
Wild Parsnip	*Pastinaca sativa*			X
Reed Canary Grass	*Phalaris arundinacea*	X		
Purple Loosestrife	*Lythrum salicaria*	X		

Table 3.6. Invasive species occurrence by management area and buffer area for the northern Lower Peninsula ecoregion.

		Occurrences of Invasive Species Within the Management Area or Five Mile Buffer																											
		Phragmites		Black/Pale Swallow Warts		Common Buckthorn		Garlic Mustard		Glossy Buckthorn		Japanese/Giant Knotweeds		Japanese Barberry		Wild Parsnip		Purple Loosestrife		Reed Canary Grass		Tartarian Honeysuckle		Amur Honeysuckle		Totals	
Management Area		MA	Buffer	MA	Buffer	MA	Buffer	MA	Buffer	MA	Buffer	MA	Buffer	MA	Buffer	MA	Buffer	MA	Buffer	MA	Buffer	MA	Buffer	MA	Buffer	MA	Buffer
MA-1	Great Lakes Islands	0	12									0	2													0	14
MA-2	Mackinaw Lake Plains	0	18							0	4					1	0	0	2	1	0	0	1			2	25
MA-3	Hammond Bay Lake Plains	0	14									0	3													0	17
MA-4	Emmet Moraines	0	2			1	1	2	3	6	5	2	1			2	2	0	1			3	11			16	26
MA-5	Cheboygan Lake Plain											0	2					0	3	0	1	1	6			1	12
MA-6	Cheboygan Basin Moraines																			0	1					0	1
MA-7	Chandler Hills	0	1	0	2			0	1			0	1			0	2	0	2			2	6			2	15
MA-8	Pigeon River Country											0	2					1	1	0	1	1	0			2	4
MA-9	Jordan Valley							0	1	0	2	0	1											0	1	0	5
MA-10	Rattlesnake Hills											0	2													0	2
MA-11	Thunder Bay Outwash																									0	0
MA-12	Alpena Lake	0	97							0	1	1	0													1	98
MA-13	Grayling Outwash							0	1																	0	1
MA-14	Grayling Ice Contact																									0	0
MA-15	Camp Grayling					0	1																			0	1
MA-16	Avery Hills											0	2													0	2
MA-17	Kirtland's Warbler					0	1																			0	1
MA-18	Benzie Moraines									4	9			0	1											4	10
MA-19	Williamsburg Moraines	0	8									0	1													0	9
MA-20	Benzie Outwash	0	1							2	11	0	1													2	13
MA-21	Boardman Plains	1	9									0	1													1	10
MA-22	Manistee Plains									4	9	0	1					0	1			0	1			4	12
MA-23	Manistee River Valley											0	1													0	1
MA-24	Houghton Lake Wetlands							0	1			1	0							0	1					1	2
MA-25	AuSable Outwash	0	1			0	1	0	1			0	4													0	7
MA-26	Wurtsmith																									0	0
MA-27	Upper Muskegon																									0	0
MA-28	Ogemaw Hills																									0	0
MA-29	Lake County Outwash																									0	0
MA-30	Lake County Moraines	0	1																							0	1
MA-31	Evart Block																									0	0
MA-32	Gladwin Lake Plain																									0	0
MA-33 SLP MA-1	Midland-Isabella																									0	0
	Total	1	164	0	2	1	4	2	8	16	41	4	25	0	1	3	4	1	10	1	4	7	25	0	1	36	289

3.5 Featured Wildlife Species

The northern Lower Peninsula ecoregion is home to approximately 200 bird species, 50 mammals, 15 amphibians, 25 reptiles and thousands of invertebrates.

The DNR Wildlife Division has a public trust responsibility for the restoration, conservation, management and enhancement of wildlife and the provisions for the public use of these resources. This responsibility is codified in Public Act 451 of 1994 and reinforced in the Division's Mission Statement and Strategic Plan. In practice, this responsibility is carried out by: 1) Managing/co-managing state-administered land; 2) Advocating/facilitating wildlife-appropriate management on other lands; and 3) Informing decisions on the regulations that affect the method and manner of take of game species. Goals for land management that affect wildlife distribution and abundance focus on providing sufficient habitat to maintain viable wildlife populations. Additional goals include providing sufficient recreational opportunities for viewing, hunting and trapping. Recognizing that resources are limited and often restricted to types of use, Wildlife Division has employed a featured species approach to prioritize land management actions.

Featured species are highly valued wildlife species with an identified habitat problem for which a practical solution exists. This plan addresses those featured species for which state forests represent a significant portion of this proposed solution. Within the context of regional state forest planning, use of the featured species approach will: 1) Help to identify and focus planning regarding current habitat conditions and threats within the region; 2) Help to more effectively prioritize and articulate a desired future condition for state forest lands across the ecoregions in relation to wildlife during this planning cycle and into the future; and 3) Allow easier communication with stakeholders regarding the status of these species and associated habitats.

This approach is consistent with the Pittman-Robertson Wildlife Restoration Act which supports the nation's cooperative conservation efforts for wildlife and their habitats. These efforts include support of resource protection strategies to sustain biological communities on managed and influenced lands and waters.

Featured species were selected using a multi-step process which was informed by U.S. Fish and Wildlife Service Strategic Habitat Conservation program (http://www.fws.gov/landscape-conservation/). Species were initially nominated by Wildlife Division staff and reviewed by teams from the Wildlife Division with assistance from other divisions within the department. In addition there was a public review process before the list was finalized. Habitat guidance for each species was developed by Wildlife Division staff with species-specific knowledge. Habitat guidance documents can be found on the DNR Wildlife Division web pages. Habitat guidance for each species includes justification, population goals, geographically-explicit priority areas (landscapes) and monitoring and evaluation recommendations.

Northern Lower Peninsula Featured Species Summaries

This section contains information on northern Lower Peninsula featured species including special listings, conservation history, habitat need, threats, as well as the specific wildlife management issue that will be addressed with this plan. Table 3.7 shows the featured species by management area for the ecoregion. Refer to Section 4 of this document for specific detail and recommended practices for featured species by management area within the species priority landscape.

American Bittern

The American bittern is listed as a species of greatest conservation need and a priority species by the Upper Mississippi River and Great Lakes Region Joint Venture. The Breeding Bird Survey has documented an average decline of 5.1% per year between 1966-2007 in Michigan, with the loss and degradation of wetlands suitable for nesting being the major factor in these declines. Breeding habitat for bitterns is primarily shallow wetlands with open water in the center and adjacent upland grasslands. Suitable wetlands are between 10 and 450 acres in size, with wetlands greater than 25 acres being used more frequently than smaller wetlands. Management should focus on protecting and maintaining wetlands and surround open grasslands, preferably those complexes greater than 50 acres in size.

American bittern is moderately vulnerable to climate change in Michigan and future populations will depend on both climate shifts and forest habitat (Hoving et al., 2013).

Table 3.7. Featured species by management area for the northern Lower Peninsula ecoregion.

NLP Management Area	American Bittern	American Marten	American woodcock	Beaver	Black Bear	Black-throated Blue Warbler	Eastern Massasauga	Elk	Golden-winged Warbler	Kirtland's Warbler	Mallard	Pileated Woodpecker	Piping Plover	Red-headed Woodpecker	Red-shouldered Hawk	Ruffed Grouse	Snowshoe Hare	White-tailed Deer	Wild Turkey	Wood Duck	Wood Thrush	Totals
MA 1 Great Lakes Islands							X					X	X			X		X				5
MA 2 Mackinaw Lake Plain			X	X	X				X		X	X		X		X	X	X	X	X		12
MA 3 Hammond Bay Lake Plain			X	X								X		X		X	X	X				7
MA 4 Emmet Moraines			X	X	X	X			X			X		X	X	X	X	X	X		X	13
MA 5 Cheboygan Lake Plain								X				X			X	X		X	X			6
MA 6 Cheboygan Basin Moraines								X				X			X	X		X	X			6
MA 7 Chandler Hills		X			X	X			X			X			X	X		X	X		X	10
MA 8 Pigeon River Country		X				X		X	X			X			X	X		X	X		X	10
MA 9 Jordan Valley		X			X	X			X			X			X	X		X	X		X	10
MA 10 Rattlesnake Hills					X		X	X	X			X			X	X		X	X			9
MA 11 Thunder Bay Outwash					X		X		X			X				X		X				6
MA 12 Alpena Lake Plain			X	X	X		X		X		X	X		X		X	X	X	X	X		13
MA 13 Grayling Outwash												X				X	X	X	X			5
MA 14 Grayling Ice Contact			X	X			X					X		X		X		X	X			8
MA 15 Camp Grayling			X				X					X		X		X	X	X	X			8
MA 16 Avery Hills					X							X			X	X		X	X			6
MA 17 Kirtland's Warbler										X	X	X					X	X	X			6
MA 18 Benzie Moraines		X			X	X						X			X	X		X	X		X	9
MA 19 Williamsburg Moraine		X	X	X	X	X	X				X	X						X	X	X	X	12
MA 20 Benzie Outwash		X	X		X	X			X		X	X			X	X		X	X	X	X	13
MA 21 Boardman Plains					X							X				X		X	X			5
MA 22 Manistee Plains			X	X	X		X		X		X	X		X		X		X	X	X		12
MA 23 Manistee River Valley	X		X	X	X		X		X		X	X				X	X	X		X		12
MA 24 Houghton Lake Wetlands			X	X	X		X		X		X	X		X		X	X	X		X		12
MA 25 AuSable Outwash	X		X	X	X		X		X		X	X		X		X	X	X	X	X		14
MA 26 Wurtsmith			X	X	X		X					X		X		X	X	X				9
MA 27 Upper Muskegon	X		X	X	X		X		X		X	X		X		X	X	X		X		13
MA 28 Ogemaw Hills	X		X	X	X							X		X		X	X	X	X	X		11
MA 29 Lake County Outwash		X	X	X	X		X		X		X	X		X		X	X	X	X	X		14
MA 30 Lake County Moraines		X	X	X	X							X		X		X	X	X	X			10
MA 31 Evart Block												X				X		X				3
MA 32 Gladwin Lake Plain			X	X			X		X			X		X		X		X				8
MA 33/SLP MA 1 Midland-Isabella			X	X					X			X		X		X		X				7
Total	4	8	19	17	21	7	15	4	17	1	11	33	1	16	10	31	15	33	23	11	7	

American Marten

The American marten was eliminated from much of Michigan in the early 1900s as a result of removal of large tracts of mature conifer forest and unregulated marten harvest. The American marten has been identified in Michigan as a species of greatest conservation need. Currently the DNR has no estimate of marten relative abundance in the northern Lower Peninsula; though several research projects, incidental harvests and road kills have provide some distribution information.

There appears to be two disjunct populations in the region, one in the southwestern portion of the ecoregion and one in the northwest. Mature conifer stands provide the structure sought by marten which are rarely found outside the forest canopy and avoid stands with less than 30% canopy cover. Marten depend on live-tree dens, snags and coarse woody debris for resting and denning sites. Dead and declining trees play an important role in marten reproduction and in the habitat requirements of their prey. The role of coarse woody debris in almost all aspects of marten ecology warrants special consideration In addition, marten need corridors between populations in order to maintain population vigor.

American marten is moderately vulnerable to climate change in Michigan and future populations will depend on both climate shifts and forest habitat (Hoving et al., 2013).

American Woodcock

The American woodcock is a valued game bird with a strong contingent of stakeholders. For example, in 2010, 36,000 hunters spent 213,000 days pursuing Michigan woodcock. The American woodcock is listed as both a species of greatest conservation need and a U.S. Fish and Wildlife Service, Upper Mississippi and Great Lakes Region Joint Venture focal species. Michigan is among the top woodcock producing states, but since the late 1960s woodcock numbers have declined by 2-3% each year. The goal for woodcock in the northern Lower Peninsula is to increase the population to 1970s levels as observed by the American Woodcock Singing-Ground Survey for Michigan. Woodcock populations across time will benefit from a balanced aspen age-class distribution and provision of display, feeding, nesting and brood-rearing habitat via upland brush, opening and poorly stocked stand management.

American woodcock is likely to Increase due to climate change in Michigan and future populations are likely to respond positively to forest habitat management (Hoving et al., 2013).

Beaver

Beaver is a valued furbearer species and in 2010, 1,300 trappers spent nearly 30,000 days afield trapping beavers in Michigan. Beavers modify their environment and the progression from pond creation, to senescence, abandonment and eventual re-vegetation is a unique cyclic disturbance regime. Beaver ponds and abandoned pond meadows provide essential conditions for many wildlife species including waterfowl, otters, warblers and woodcock. Beaver activity also promotes the maintenance of diverse wetland and riparian communities. Beavers prefer relatively narrow, low gradient streams of less that 15% slope with emergent vegetation and abundant alder, aspen, birch, maple or willow. Beaver depend upon water depths sufficient for under-ice travel and feeding. Reduction in beaver abundance can result in a decrease in this disturbance regime and a suite of associated wildlife. The beaver population in the northern Lower Peninsula appears to be healthy and the goal is to maintain the population at present levels. Beaver prefer to forage within 100 feet of streams.

The population of beaver is presumed stable due to climate change and large changes positive or negative impacts due to climate change are not expected (Hoving et al., 2013).

Black Bear

The black bear is a highly valued big game species throughout northern Michigan. In 2010, 37,000 hunters applied for 12,000 available bear licenses and hunters spent more than 55,000 days afield hunting. There are at least seven well-established stakeholder groups supporting bear management. In addition, viewing bears is valued by hunters and non-hunters alike. In 2011 the department recommended reducing the bear population in the northern Lower Peninsula over the next four years. Hard mast is critical for bears during the fall months to achieve adequate weight gains before denning. Black bear also benefit from small forest clearings and maintaining an oak component in stands.

The population of black bear is presumed stable due to climate change and large changes positive or negative impacts due to climate change are not expected (Hoving et al., 2013).

Black-throated Blue Warbler

The black-throated blue warbler is a species of greatest conservation need, a U.S. Fish and Wildlife Service Region 3 Resource Conservation Priority and a Partners in Flight priority bird species. This warbler has a limited range in Michigan and low densities in suitable habitat. Diverse vertical forest structure is important to conserving Michigan populations. The goal for black-throated blue warblers is to maintain stable breeding populations in priority landscapes. Black-throated blue warblers benefit from mature, large (>50 years old, >250 acres) mesic deciduous forest tracts with a dense understory layer for nesting and foraging.

Black-throated blue warbler is likely to increase due to climate change in Michigan and future populations are likely to respond positively to forest habitat management (Hoving et al., 2013).

Eastern Massasauga Rattlesnake

The eastern massasauga rattlesnake is the only free-ranging venomous snake in Michigan. The species is a candidate for federal listing by the U.S. Fish and Wildlife Service (USFWS, 1999) and the department is in the process of finalizing a Candidate Conservation Agreement with Assurances (Michigan Department of Natural Resources, 2013). The greatest threat to this snake is the loss and degradation of habitat due to the draining of wetlands, and the conversion of open areas to shrubland or woodlands. The goal for massasauga in the northern Lower Peninsula is to maintain species presence at sites currently occupied by following the standards established in the Candidate Conservation Agreement with Assurances once it is completed.

Eastern massasauga rattlesnake is highly vulnerable to climate change in Michigan. The long-term sustainability of eastern massasauga rattlesnake will depend on more on climate shifts than on forest habitat (Hoving et al., 2013).

Elk

Elk is a valued wildlife species in the northern Lower Peninsula. Elk-related tourism is important for the economies of many communities in the region and the annual hunt draws over 35,000 applicants yearly for 100-400 permits. The challenge for elk management is balancing the desire for large numbers of elk for tourism and hunting while minimizing the negative impacts of elk on agriculture and forestry. In addition, improvements in elk habitat in the core range will help minimize any negative impacts outside of the core. The goal for elk in the northern Lower Peninsula is to maintain the population at 500-900 animals as measured in the biennial aerial survey. Elk require early successional cover types, openings and hard mast.

The population of elk is presumed stable due to climate change and large changes positive or negative impacts due to climate change are not expected (Hoving et al., 2013).

Golden-winged Warbler

Michigan populations of golden-winged warbler have experienced significant long term declines averaging over 8% per year since 1966. This decline is attributed to loss of breeding habitat and competition or hybridization with the blue-winged warbler. These warblers nest in a variety of shrubby and early-successional forest sites including moist woodlands, willow and alder thickets and young forests of sapling aspen and cherry. Limited tree canopy cover appears to be important yet 'residual' trees within clear-cuts or forest edges adjoining clearings are preferred. The goal for golden-winged warbler in the northern Lower Peninsula is to maintain stable breeding populations in priority landscapes as indicated by continued presence in occupied stands over the course of the planning cycle. Golden-winged warblers thrive in young aspen (0-10 years old) in association with lowland shrub and grasslands.

Golden-winged warbler is likely to increase due to climate change in Michigan and future populations are likely to respond positively to forest habitat management (Hoving et al., 2013).

Kirtland's Warbler

Kirtland’s warbler is the rarest neotropical migrant in North America, is a federal and state listed endangered species, a species of greatest conservation need species, and a Joint Venture land bird species. It is considered a conservation-reliant species meaning that managing jack pine in large patches with relatively high stem densities is necessary to sustain a viable population. The goal for Kirtland’s warbler is to maintain a population of at least 1000 nesting pairs as indexed by the annual breeding survey. Kirtland’s warbler benefits from large patches (300 to 550 acres) of early successional jack-pine forest with appropriate structural and compositional diversity on droughty outwash plains systems.

Kirtland’s warbler is likely to increase due to climate change in Michigan and future populations are likely to respond positively to forest habitat management (Hoving et al., 2013).

Mallard

Mallards are a highly valued game species in Michigan and represent approximately 47% of the state’s annual duck harvest. There has been a long-term decline in the estimated number of Michigan’s breeding mallards; down from 567,000 in 1998 to 259,000 in 2009. The loss or degradation of Michigan’s emergent wetlands is the primary habitat concern. The goal is to maintain 420,000 breeding mallards in Michigan, when Great Lakes water levels are near their long-term average.

The population of mallard is presumed stable due to climate change and large changes positive or negative impacts due to climate change are not expected (Hoving et al., 2013).

Pileated Woodpecker

The pileated woodpecker creates large cavities for nesting and during foraging activity. They do not reuse nest sites, so the cavities become available for cavity-dependent animals which cannot excavate their own cavities. There is strong competition both within and between species of secondary cavity nesters for the limited supply of pileated woodpecker nests, including wood duck, common goldeneye, bufflehead, hooded merganser, common merganser, merlin, kestrel, screech-owl, saw-wet owl, barred owl, fisher and American marten. Only large-diameter trees have sufficient girth for nest and roost cavities. Thus, there is concern for populations of this woodpecker and species dependent upon it where late-successional forests are converted to younger habitat conditions or where young forests are not allowed to mature. Mature forest including large diameter living and dead standing trees (for cavities) are important habitat requirements for this species.

The population of pileated woodpecker is presumed stable due to climate change and large changes positive or negative impacts due to climate change are not expected (Hoving et al., 2013).

Piping Plover

Piping plover is a state and federally listed endangered species that nest and forage in open, sparsely-vegetated sandy coastal habitats. The U.S. Fish and Wildlife Service has designated critical habitat for this species along portions of northern Lower Peninsula Great Lakes shorelines. Plovers use both the beach and fore-dune areas and wetlands between the dunes. These areas have significant biodiversity value and provide habitat for many species of Great Lakes endemic and rare plants such as Houghton’s goldenrod, Pitcher’s thistle and Lake Huron tansy and the rare insect the Lake Huron locust. Other species of note sharing the beach with piping plover include Caspian terns, spotted sandpiper, bald eagle, merlin and numerous migrating shorebirds and waterfowl. The protection of shoreline areas and enforcement of off-road vehicle laws is critical to maintain piping plover habitat.

Piping plover is moderately vulnerable to climate change in Michigan and future populations of will depend on both climate shifts and forest habitat (Hoving et al., 2013).

Red-headed Woodpecker

Michigan populations of red-headed woodpecker have experienced an average annual decline of 6.2% since 1966. These declines have been attributed to the loss of preferred snags and trees. The goal is to increase breeding populations in the eco-region as observed in the North American Breeding Bird Survey for Michigan.

Red-headed woodpecker is likely to increase due to climate change in Michigan and future populations are likely to respond positively to forest habitat management (Hoving et al., 2013).

Red-shouldered Hawk

The red-shouldered hawk is a U.S. Forest Service regional forest sensitive species, a state-threatened species and a Species of Greatest Conservation Need. Additionally, it is a U.S. Fish and Wildlife Service, Region 3, conservation priority as a rare/declining species. In the early 1900s, red-shouldered hawk numbers decreased along with declines in mature lowland deciduous forests habitat. Although Michigan red-shouldered hawk populations are currently believed to be stable, they are sensitive to decreases in suitable forest cover and preferred nest trees and increased forest fragmentation. Red-shouldered hawk prefer hardwood forest stands greater than 385 acres in size with some large diameter at breast height trees.

The population of red-shouldered hawk is presumed stable due to climate change and large changes positive or negative impacts due to climate change are not expected (Hoving et al., 2013).

Ruffed Grouse

The ruffed grouse is an important game bird in Michigan with approximately 85,000 hunters spending 616,000 days hunting grouse in 2010. Michigan is recognized nationally for grouse production and hunting opportunity. Although ruffed grouse use many different cover types, aspen can support the highest densities of grouse. Optimum habitat includes young (6-15 year old) even-aged deciduous stands that typically support 8-10,000 woody stems per acre. A balanced aspen age-class distribution and provision of soft browse should contribute to the provision of long-term sustainable ruffed grouse populations.

The population of ruffed grouse is presumed stable (elsewhere) due to climate change, but the population is likely to shift out of Michigan. Future populations of ruffed grouse are more likely to respond to climate trends rather than forest habitat management (Hoving et al., 2013).

Snowshoe Hare

The snowshoe hare is a valued game species in across the northern part of the state and during 2010 15,000 hunters spent about 103,000 days in the field hunting this species. Snowshoe hare are an important prey species for many furbearers including pine marten, bobcat and other medium size carnivores. Today there is a low relative abundance of hare throughout southern extent of its range which includes the northern Lower Peninsula. Declines likely result from a reduction in habitat quality (young forest with regenerating mesic conifer); however, climate change may also play a role. Hare populations do best in areas of dense, young forest and shrub communities; alder and coniferous swamps are preferred. Dense understory cover is the primary limiting factor and escape and thermal cover is more important than food availability. Priority habitat needs include maintaining early successional forest (jack pine, mixed swamp conifer, tag alder, and aspen), especially in areas adjacent to lowlands, promotion of retaining and restoring the mesic conifer component within stands and maintenance or enhancement of leaving coarse woody debris following harvest.

Snowshoe hare is highly vulnerable to climate change in Michigan. The long-term sustainability of snowshoe hare will depend on more on climate shifts than on forest habitat (Hoving et al., 2013).

White-tailed Deer

White-tailed deer are the most highly valued game species in the state and deer hunting contributes significantly to local economies. Deer are a keystone species and can have significant impacts (positive and negative) on vegetative communities. In 2010, 656,500 hunters spent 9.6 million days afield in Michigan hunting deer with the largest number of participants and stakeholder groups of any game species.

In the northern Lower Peninsula overwinter survival can be a limiting factor and mortality has exceeded 15% of the population in severe winters. Nutritious spring forage, particularly adjacent to wintering complexes, is critical to recovery from winter stress.

White-tailed deer statewide are not likely to increase or decrease due to climate change. However, the patterns of habitat use by white-tailed deer in northern Michigan are likely to shift as snowfall patterns change. Snowfall is a major driver of deer migratory behavior and their restriction to wintering complexes of mature conifers. Current trends toward more winter precipitation and less lake ice have resulted in significant increases in snowfall over the past 30 years, even as temperatures have increased. Thus, deer wintering complexes of mature conifers remain important. At some point, increasing temperatures will cause more snow to fall as rain, winter severity will decrease and the importance of deer wintering complexes will decrease. When deer become less restricted to wintering complexes, the spatial impact of deer browse will change. The timing of this shift is highly uncertain.

Wild Turkey

The wild turkey is a highly valued game bird in Michigan and the northern Lower Peninsula. During the 2009 spring season, 120,000 hunters spent 450,000 days afield pursuing turkeys. As a result of successful introduction efforts and winter feeding programs over the past half century, turkeys are now present across the entire northern Lower Peninsula. Population increases have leveled-off and there is concern that land use changes could erode the recent advances in turkey numbers. Provision of natural winter food, maintaining and regenerating the oak component within stands and maintaining brood-rearing openings will improve turkey brood-production and winter survival.

Wild turkey is likely to increase due to climate change in Michigan and future populations of are likely to respond positively to forest habitat management (Hoving et al., 2013).

Wood Duck

The wood duck is a valued game species and is listed as Upper Mississippi River and Great Lakes Joint Venture focal species. Recent regional population estimates were 17% below goals established by the Joint Venture. Wood ducks use a wide range of wetland habitat types throughout the year including riparian areas, wooded swamps, marshes, bottomlands and beaver ponds. Areas with open water and approximately 50-75% cover are preferred. Cavity trees, herbaceous emergent plants, flooded shrubs and downed timber providing cover are also important habitat features. Cavity trees, herbaceous emergent plants, flooded shrubs and downed timber providing cover are also important habitat features. Maintaining forest wetland, riparian corridors with suitable habitat is important for wood ducks.

The population of wood duck is presumed stable due to climate change and large changes positive or negative impacts due to climate change are not expected (Hoving et al., 2013).

Wood Thrush

The wood thrush is listed as a species of greatest conservation need, a Partners in Flight priority species and an Upper Mississippi River and Great Lakes Region Joint Venture focal species. Michigan populations have declined at an average annual rate of 2.1% per year for the past 43 years, primarily because of forest fragmentation. Wood thrushes are susceptible to nest predation and brood parasitism and both increase with forest fragmentation. Nesting birds occur primarily in upland, mesic deciduous and mixed forests with large trees, diverse tree communities, moderate undergrowth and a well-developed litter layer. Wood thrush prefer large (>250 acres) forest tracts, minimizing edges and promoting a dense understory layer for nesting and foraging activities.

Wood thrush is likely to increase due to climate change in Michigan and future populations of are likely to respond positively to forest habitat management (Hoving et al., 2013).

Summary of Priority Habitat Elements

As the summaries above indicate, there is a high degree of overlap in the conservation/habitat needs of many of the featured species. These needs can be categorized into broad categories and include: 1) Forest Structure and Dead wood; 2) Grasslands; 3) Great Lakes Coast; 4) Extensive Mature Forest; 5) Oak Mast; 6) Wetland and Lowland Complexes; and 7) Young Forest. Table 3.8 summarizes the relationship of featured species to habitat need categories.

Table 3.8. Summary of habitat need categories for featured species in the northern Lower Peninsula ecoregion.

	Priority Wildlife Habitat Elements						
Species Name **bold** = statewide ***italic*** = regional	Forest Structure/Dead wood	Grasslands	Great Lakes Coast	Mature Forest	Oak Mast	Wetland and Lowland Complexes	Young Forest
American bittern		X				X	
American marten	X			X			
American woodcock						X	X
beaver						X	X
black bear	X				X		X
black-throated blue warbler	X			X			
eastern massasauga		X					
elk		X			X		X
golden-winged warbler						X	X
Kirtland's warbler							
mallard		X				X	
pileated woodpecker	X			X			
piping plover			X				
red-headed woodpecker	X				X	X	
red-shouldered hawk	X			X			
ruffed grouse					X		X
snowshoe hare	X					X	X
wild turkey		X			X		X
white-tailed deer	X	X			X		X
wood duck	X				X	X	
wood thrush	X			X			
Total	10	5	1	5	7	8	9

3.6 Water Quality and Fisheries

Most of Michigan's watersheds were historically forested. Most watersheds in the northern Lower Peninsula have high levels of deforestation resulting from human development for agriculture, residential and urban use. Watershed scale deforestation in lower Michigan has been shown to affect the hydrology of streams and lakes, changing flow patterns, channel characteristics and various habitat components including water quality (Wang et al., 2008). Fisheries Division studies have found that the level of forest cover shading the stream channel is one of three important factors influencing water temperatures in Michigan streams, the other two being channel morphology and ground water inputs (Wehrly et al., 1998). More current research has suggested a more complex picture suggesting that stream temperatures are influenced by a much broader suite of factors (Wehrly et al., 2006). Regardless, maintaining and restoring riparian forests are important components of maintaining stream temperatures and hence stream biota (Wehrly et al., 1998).

The relationship between the proportion of a watershed that is harvested (temporary deforestation) as part of forest management operations and when stream temperatures begin to rise is complex and has not been well documented. Also, there has been little work in the area of determining resilience – how long is the period of time that it takes for stream temperature to return to normal levels as the harvested forest regenerates or what is the proportion of the watershed that can be maintained in a deforested state without impacting stream temperature (recognizing that the spatial distribution of temporarily deforested harvest areas move around the landscape). As a result there are no guidelines for use in forest management planning or implementation that relate to the proportion of a watershed that can be harvested without having a negative impact on stream temperature. It is known that stream temperature, stream flow and water quality can be impacted by forest operations within what is called a riparian or riparian management zone adjacent to the stream channel.

Riparian areas of lakes and streams provide critical benefits for aquatic resources, including:

- Protection from sunlight and cold that helps maintain natural water temperatures during winter and summer;
- Maintaining natural cycles of water infiltration and evapotranspiration;
- Natural shoreline vegetation for stabilizing stream banks and lake shorelines against unnatural erosion, critical amphibian and reptile habitat and provision of terrestrial litter and insects into surface waters for direct food sources and aquatic food webs; and
- Attenuating floods and runoff to help maintain water quality.

The DNR uses riparian cover management guidelines, often referred to a best management practices, as described in IC4011 *Sustainable Soil and Water Quality Practices on Forest Land* (DNR and DEQ, 2009) to protect riparian management zones on lakes and streams. The riparian management zone is a strip on each side of perennial or intermittent streams or around the perimeter of water bodies (e.g., open water wetlands, ponds and lakes). The riparian management zone is not a “no cut buffer;” it is a zone where extra precaution will be used in harvesting timber or where such related activities as log landings, road construction, stream crossings or site preparation are not permitted or minimized.

Status and Trends of Inland Streams

Coldwater resources are more limited than coolwater/warmwater resources in the northern Lower Peninsula ecoregion. Only 36% of Lower Peninsula stream segments are classified as coldwater (Wehrly et al., 1999) and many of these streams are located in the northern Lower Peninsula ecoregion. The stable influx of cold groundwater coming from the elevated coarse glacial deposits creates conditions conducive to naturally reproducing trout populations in most northern Lower Peninsula streams. The best trout producing streams have cold summer temperatures with sufficient gravel or cobble for spawning. Generally, waters in the northern Lower Peninsula support diverse aquatic communities and are commonly found to have good-to-excellent water quality (Wolf and Wuycheck, 2004).

Historically, nearly all rivers in the northern Lower Peninsula ecoregion have been altered greatly by the effects of logging, through the removal of timber, increased erosion and the use of check dams and the resultant channel changing flow surges. Channel morphology has been altered for many streams as a result of these historic logging practices past and from past or present peaking operations at hydropower dams. With relative flow stability, many high quality trout streams lack the ability to quickly recover from these past perturbations. Dams (including those constructed by beaver) can also affect the temperature and flow regime of a stream, often to the point of where they impact the downstream aquatic community and stream’s ability to sustain a natural trout population. Dams also affect stream ecology by interrupting the transport of sediments and large woody material.

DNR Policy and Procedure 39.21-20 – Beaver Management addresses high priority trout streams (Appendix F) where beaver have the potential to cause unacceptable degradation of cold water stream quality.

Potential Impacts of Climate Change on Aquatic Ecosystems

Given that the impacts on stream temperature from changes in land cover and land use will be of similar or greater magnitude as from increasing air temperature (Wehrly et al., 2006), global warming has the potential for widespread impact on aquatic ecosystems and biota. There may be a shift of some cold water streams to cool water conditions and cool water systems to warm water systems with a corresponding change in biotic communities.

3.7 Socioeconomic Context

Concurrently with the U.S. Department of Agriculture Forest Service, the DNR held a series of 53 focus group meetings in 1996 for the purpose of gaining information about the public's views, visions and concerns regarding the management of public lands in the northern Lower Peninsula ecoregion. Participants in these meetings identified the following values and uses as being important for the ecoregion (Tessa Systems, LLC 2006):

- Low population, less traffic and absence of urban characteristics;
- Slower, friendlier lifestyle;
- Small town environment;
- Beauty and solitude of lakes, rivers and the natural environment;
- Nearness to public lands;
- Clean air, open spaces, the four seasons and the pristine environment;
- Hunting, fishing, viewing wildlife and other recreational activities; and
- Raw materials for manufacturing and good transportation networks.

The state forest lands in the northern Lower Peninsula ecoregion contribute to these values and uses by providing many human uses and ecosystem services, including biodiversity conservation; timber production; recreational activities; oil, gas and mineral production; public education; and research. Sustainable forest management is greatly influenced by the demands of each of these uses which shape the management direction of the state forest. As the population of the northern Lower Peninsula ecoregion continues to grow into the future, the importance of the beauty and solitude of the lakes, rivers and the natural environment, particularly on public land will also continue to grow. In particular, demand for available outdoor recreational opportunities will continue to put pressure on the ability of the system to meet demand.

3.7.1 Timber Production

Production of timber products through management of state forest lands contributes to the local economy in many communities throughout the northern Lower Peninsula. As of 2005, there were a total of more than 7,000 jobs in forest product industries. There were more than 90 businesses involved in forestry and logging and wages for the forestry and logging, wood products and paper manufacturing sectors that totaled over $110 million (DNR Communication, 2006). Wages for the forestry and logging economic sector totaled $15.9 million in 2005 (Michigan Department of Labor and Economic Growth). In the northern Lower Peninsula there were 91 establishments involved in forestry and logging in 2005 (Michigan Department of Labor and Economic Growth). Even though the latest downturn in economic activity has impacted the timber industry in Michigan, the overall economic of forest products is still significant in many communities through the northern Lower Peninsula region. Figure 3.4 shows that there was not much change in the either the acres harvested or the volume of the harvest over the last ten years.

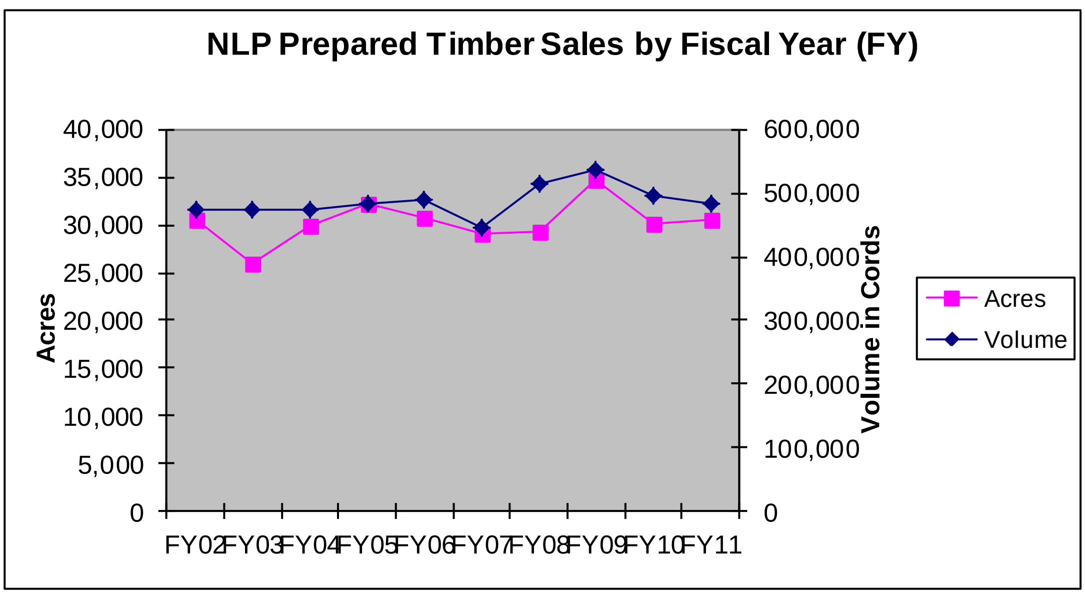

Figure 3.4. Acreage and volume of state forest timber sales in the northern Lower Peninsula ecoregion (2012 unpublished Department of Natural Resources timber sale data).

3.7.2 Forest Recreation and Tourism

In a 2007 survey of registered Michigan voters, which was generally representative of the Michigan population, more than half (51%) cited outdoor recreation as very important to their households, while 35% reported it moderately important and the remaining 14% reported it as slightly important or unimportant. More than half the responding households reported that one or more members walked outdoors, relaxed outdoors, picnicked, bicycled, did sightseeing, drove for pleasure, swam outdoors and fished in the past year. When asked about the three most important activities to their household, walking outdoors, relaxing outdoors, fishing, hunting and camping were the five most commonly cited. In the past year, 75% of respondent households had one or more members that visited a public outdoor recreation venue, with 60% noting a visit to a state property, 53% to a local park and 23% to federal lands. Of those who had one or more visits, 38% said they had more than 10 outdoor recreation visits to public lands in the past year. (Michigan Statewide Comprehensive Outdoor Recreation Plan 2008-2012).

Forest based recreation is also very important to the tourism economy of the northern Lower Peninsula ecoregion. The state forests of the northern Lower Peninsula ecoregion provide two million acres of land for hiking, biking, riding trails, hunting, enjoying solitude, fishing, picking mushrooms and berries, camping, bird watching and gathering firewood. There are 40 state-operated pathways providing a total of 360 miles of hiking, biking or skiing trails; 185 forest campgrounds providing almost 1,900 camping sites; and hundreds of miles of snowmobile, off-road vehicle and horse trails.

For the entire state forest system, it was estimated in 1999 that there were over 23 million visits for all recreation purposes. As studies have shown, proximity to population centers, such as Southern Michigan, increases use of forest areas for recreation and the majority of these 23 million state forest visits are probably in the northern Lower Peninsula.

3.7.3 Hunting, Trapping, and Fishing

The U.S. Fish and Wildlife Service, in collaboration with the Bureau of Census, conducts a periodic national survey of fishing, hunting and wildlife-related recreation and Michigan-specific reports were developed for the 1996, 2001 and 2006 surveys (U.S. Department of the Interior Fish and Wildlife Service and U.S. Department of Commerce Bureau of the Census 1998, 2003 and 2008). In September of 2012, preliminary results from the 2011 survey were released. The surveys compile data on hunter and angler characteristics, participation and expenditures. The 2006 results showed that over 1.7 million residents and non-residents hunted, trapped or fished in Michigan. Economic activity related to these recreational pursuits represents a significant revenue source for the state and local economies. For 2006, it is estimated that total expenditures were over $900 million for hunting and trapping and over $1.6 billion fishing. In addition, state forests provide opportunities for wildlife-watching and these activities contribute another $1.6 billion dollars in annual economic activity.

The Wildlife and Fisheries divisions conduct regular surveys of hunters, trappers and anglers to estimate levels of effort and harvest success. Based on 2011 data, there are nearly 700,000 deer hunters, over 100,000 turkey hunters, over 250,000 small game hunters and over 1.2 million anglers. These are statewide values and include activities on all lands, yet the state forest system with nearly four million acres open to hunting, trapping and fishing represents a significant proportion of the land open to recreation in the state.

3.7.4 Oil, Gas, and Mineral Production

Oil and gas development is also economically important throughout the region. There are five significant oil and gas producing geologic formations that overlap in the northern Lower Peninsula ecoregion. These formations include the Traverse, Dundee and Richfield Formations; the Niagaran Reef Trend; the Glenwood and Prairie du Chien Formations; the Antrim Shale Formation; and the Collingwood Formation. There has recently been increased interest in natural gas exploration and development in the Collingwood Formation. The relationship between wells and the state forest lands are shown in Figure 3.4.

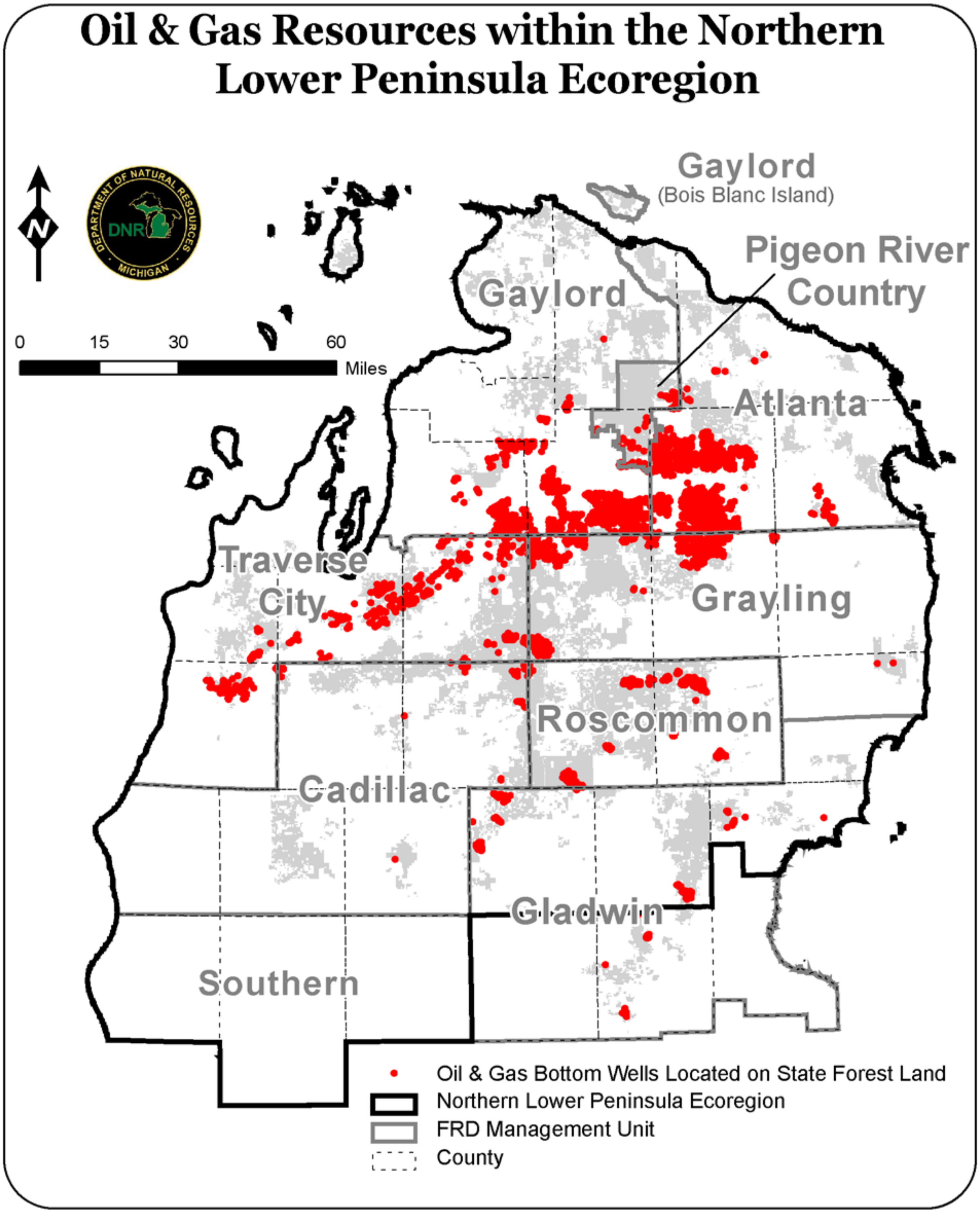

Figure 3.4. A map of the northern Lower Peninsula showing the relationship among oil and gas wells, sour gas wells, storage facilities and the state forest land.