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Superior National Forest Land and Resource Management Plan

Monitoring and Evaluation Report 2009-2017

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Summary of Findings and Recommendations

Section 5.0 Monitoring Results contains recommendations for each resource area discussed in this report. The recommendations for each resource area highlights and discusses potential changes in monitoring and management methods. No recommendations recognized a need to revise or amend the 2004 Superior National Forest Land and Resource Management Plan (Forest Plan).

Monitoring results for past, ongoing, and future resource management and Forest Plan implementation included general recommendations for:

- Considering resource management options for moving toward or meeting Forest Plan objectives and desired conditions.
- Improving monitoring methods used in addressing the Forest Plan Chapter 4 Monitoring and Evaluation.
- Ensuring continued compliance with Forest Plan standards and guidelines.
- Continuing to use resource management and monitoring methods effective in meeting Forest Plan objectives and desired conditions.
- Managing monitoring data collected responding to monitoring questions and indicators.
- Identifying potential research and coordination with researchers to inform resource management and Forest Plan implementation.
- Continuing to do the management activities, monitoring, and evaluation that is successful in Forest Plan implementation, and continuing to look for ways to refine efforts that can be improved.

The recommendations in this report are numerous and wide ranging. Considering the finite amount of funds, personnel, and other resources available to the Superior National Forest, it is unlikely that the Superior National Forest will be able to adopt all of the recommendations made in this report. Available funds, resources, staffing and partnerships will be key considerations in addressing and adopting recommendations.

1.0 Introduction

Effective Land and Resource Management Plan (Forest Plan) monitoring and evaluation fosters improved management and more informed planning decisions. It helps identify the need to adjust management direction, such as desired conditions, goals, objectives, standards and guidelines, as conditions change. Monitoring and evaluation helps the Agency and the public determine how a Forest Plan is being implemented, whether plan implementation is achieving desired outcomes, and whether assumptions made in the planning process are valid.

Monitoring and evaluation are learning tools that form the backbone of adaptive management. With these tools, information is collected and compiled to serve as reference points for the future; new scientific understanding and technology, changes in law, policy and resource conditions, growing concerns, trends and changing societal values are incorporated into land management planning; and the scientific validity and appropriateness of assumptions used in the development of the Forest Plan is evaluated. In short, they breathe life into a static document—the Forest Plan—to make it dynamic, relevant, and useful.

Several kinds of activities can be referred to as "monitoring." Programmatic monitoring tracks and evaluates trends of ecological, social, or economic outcomes. Project implementation monitoring monitors compliance with Forest Plan standards and guidelines. Effectiveness monitoring evaluates how effective our management actions are at achieving desired outcomes. Validation monitoring verifies assumptions and models used in Forest Plan implementation. Monitoring may also address issues for large geographic areas of which the Forest is a part.

The M&E Report is of value to Forest Service leadership, managers and employees, as well as to the public. The information gained from monitoring is used to determine how well the desired conditions, goals, objectives, and outcomes of the Forest Plan have been met. The M&E Report provides a readily available reference document for Forest Service managers as they plan, evaluate the effects of actions on resources, and implement future projects. This information can illuminate changes needed in project planning and implementation, or changes needed in Forest Plan direction. This report also describes to the public how their public lands are being managed and how effectively the commitments made to them within the Forest Plan are being met.

This M&E Report contains compiles and considers data collected since the 2009 Superior National Forest M&E Report through the Superior's annual data freeze in December 2017. The Superior's next biennial report will consider monitoring results through to December 2019. Due to budget and staffing limitations, monitoring results for recreation and heritage resources are not reported on in this report.

2.0 Monitoring & Evaluation Requirements

Minimum monitoring and evaluation requirements have been established through the National Forest Management Act (NFMA) at 36 CFR 219. Some requirements provide guidance for the development of a monitoring program, while others include specific compliance requirements.

Monitoring and evaluation are separate, sequential activities required by NFMA regulations. Monitoring involves the repeated collecting of data by observation or measurement. Evaluation involves analyzing and interpreting monitoring data. The information gained from monitoring and evaluation is used to determine how well the desired conditions, goals, objectives, and outcomes of the Forest Plan are being met. Monitoring and evaluation are critical steps in the process of keeping the Forest Plan responsive to changing conditions, thereby providing the feedback mechanism for an adaptive management framework. The results are used to identify when changes are needed to the Forest Plan or the way it is implemented.

Forest Plan Monitoring on the Superior National Forest has three major components: the Monitoring Program (contained within the Forest Plan), the Monitoring Guide, and the Monitoring and Evaluation Report. Each are described below.

2.1 Monitoring Program

The monitoring program contained within the Forest Plan is strategic in nature and provides programmatic direction for monitoring and evaluating Forest Plan implementation. The monitoring program addresses several types of monitoring. These requirements fall into four broad categories:

Category 1: Required monitoring items (NFMA and 36 CFR 219 regulations)

Category 2: Attainment of goals and objectives

Category 3: Implementation of standards and guidelines and

Category 4: Effects of prescriptions, management practices, and off-road vehicles

Required Category 1 monitoring items are mandatory components of every Forest Plan, whereas Category (2) through (4) monitoring items are more flexible and tailored to address issues raised through public scoping and interdisciplinary team review. A more complete description of Category 1 through 4 monitoring items can be found in Chapter 4 of the 2004 Forest Plan.

Budgetary constraints may affect the level of monitoring that can be done in a particular fiscal year. If budget levels limit the Forest's ability to perform all monitoring tasks, then those items specifically required by law are given the highest priority.

2.2 Monitoring Guidelines and Components (Monitoring Guide)

The Monitoring Guidelines and Components (Monitoring Guide) is part of the overall monitoring framework for the Superior National Forest and discussed in the Forest Plan Chapter 4 Monitoring and Evaluation. While Chapter 4 is strategic in nature and provides programmatic direction for monitoring and evaluating Forest Plan implementation, the Monitoring Guide provides direction that is more specific to implement the monitoring strategy outlined in the Forest Plan. The Monitoring Guide details the methodologies and protocols used to conduct monitoring and evaluation tasks identified in the 2004 Forest Plan for the Superior National Forest. The Monitoring Guide also assigns responsibilities for monitoring and evaluation tasks, and addresses information management, evaluation, interpretation, and public involvement..

The Monitoring Guide is flexible and may be changed as new methodologies and techniques are developed. It allows the principles of adaptive management to be applied so that as monitoring techniques are implemented they can be evaluated for their effectiveness and efficiency (and revised as appropriate).

2.3 Monitoring and Evaluation Report (M&E Report)

Providing timely, accurate monitoring information to the decision makers and the public is a key requirement of the monitoring and evaluation strategy. The monitoring and evaluation report, which provides the analysis and summary of the monitoring results, is the vehicle for disseminating this information. As stated on page 4-6 of the 2004 Forest Plan this report, "…provides an opportunity to track progress towards the implementation of Forest Plan decisions and the effectiveness of specific management practices. The focus of the evaluation is in providing short and long-term guidance to ongoing management."

Evaluation is the process of transforming data into information—a value-added process. It is a process of synthesis that brings together value, judgment and reason with monitoring information to answer the question, "So what?" and perhaps, "Why?" Evaluation requires context. A sense of the history of the place or the circumstances (temporal and spatial context) are important to the evaluation of management activities. Evaluation describes movement from a known point (base line or reference condition) either toward or away from a desired condition. The desired conditions may or may not ever be fully achieved, but it is important to know if management activities are heading in the right direction. Evaluation produces information that is used to infer outcomes and trends: Conclusions will be drawn from an interpretation of evidence. These conclusions are documented in the Monitoring and Evaluation Report.

The Monitoring and Evaluation Report is intended to be a comprehensive compilation of all the monitoring and evaluation described in the plan. This report will provide summaries of data collected, and complete evaluations of the data. The evaluation process determines whether the observed changes are consistent with Forest Plan desired conditions, goals, and objectives and identifies adjustments that may be needed. Continuous updating and evaluation of monitoring data provides a means to track management effectiveness from year to year and to show the changes that have been made or are still needed.

Key information displayed in the Monitoring and Evaluation Report includes:

- Forest accomplishments toward achieving multiple use objectives for providing goods and services.
- The degree to which on-the-ground management is maintaining or making progress toward the desired conditions and objectives for the plan
- The effects of the various resource management activities within the plan area on the productivity of the land
- Conclusions and recommendations regarding the need to adjust monitoring or change the Forest Plan
- Status of other agency/institution cooperative monitoring
- Update of research needs
- Documentation of any monitoring that has not been completed and the reasons and rationale (budget or staffing limitations or unexpected conditions, such as a severe fire season)

3.0 History of Monitoring Activities on the Superior National Forest

Since the Record of Decision was signed for the 2004 Superior National Forest Land and Resource Management Plan, Monitoring and Evaluation Reports were published for years 2005 through 2009. These reports are available on the Superior National Forest website Monitoring page.

This section describes Forest Plan monitoring since the 2009 Monitoring and Evaluation Report, which is available on the Superior National Forest website.

While the Superior National Forest has not published a Monitoring and Evaluation Report since the 2009 report, the Forest has conducted annual and regular Forest-wide monitoring. Data and evaluation of the monitoring efforts are maintained Superior National Forest files. Information from monitoring efforts informs ongoing project analyses, decision making, and Forest Plan implementation.

In 2012 the requirements for monitoring changed from the 1982 rule to the 2012 Planning Rule., thus the monitoring program on the Superior National Forest changed due to the monitoring transition. The Superior National Forest monitoring program developed to be consistent with the 2012 rule and is available on the Forest's website, Superior National Forest Administrative Change - Chapter 4 Monitoring and Evaluation.

4.0 Monitoring Program Transition

The Land and Resources Management Planning regulations (36 CFR 219), published in 2012, changed Forest Plan monitoring program requirements for all national forests. Any national forest that did not plan to initiate a revision to their Forest Plan prior to May 9, 2016 needed to

update their monitoring program to meet the new requirements of the 2012 Planning Rule. This update (referred to as monitoring program transition) had to occur no later than May 9, 2016.

Because the Superior National Forest did not initiate the process of Forest Plan revision prior to May 9, 2016, the Superior administratively changed its Forest Plan monitoring program as part of the required monitoring program transition. Most of the new Forest Plan monitoring required by the 2012 Planning Rule was already addressed in the Superior National Forest's monitoring program. However, some changes were needed to be in full compliance. Superior National Forest managers invited comment on proposed changes and addressed comments received in further development of our monitoring program.

The changes to the monitoring program were an administrative change. The Superior's monitoring program, including its monitoring questions, is posted on its website on the Monitoring page, Superior National Forest Administrative Change - Chapter 4 Monitoring and Evaluation.

5.0 Monitoring Results

5.1 Air Quality and Smoke Management

Air quality is a core physical resource influencing many other resources on the Superior National Forest (SNF or Forest). For example, acidic precipitation can degrade forest soils, water quality, and aquatic communities. Mercury deposition can make fish unfit for human consumption, which is an adverse impact on recreation on the Forest. Mercury contaminated fish can also adversely affect wildlife that consume fish. Polluted air can directly affect the health and growth of Forest vegetation. Resource effects caused by poor air quality are termed "air quality related values" and the Clean Air Act for the Boundary Waters Canoe Area Wilderness (BWCAW) protects them.

The Forest boundary, both outside and inside, contains sources of air pollution. Most air pollution experienced on the SNF is a regional scale phenomena caused by many sources from Minnesota, the surrounding region, and beyond. Primary sources include coal-fired power plants, taconite plants, and vehicles (MPCA RH Rule). Notable sources within the SNF include wildfires and certain project management activities, particularly prescribed burning. Due to its location being far from large numbers of urban and/or industrial sources, the SNF has some of the cleanest air in the eastern US.

The most recent monitoring and evaluation reporting for air quality related to the Superior National Forest was for fiscal year 2009.

5.1.1 Air Quality Related Values Monitoring Question #1

Are air quality related values (AQRVs) of the Boundary Waters Canoe Area Wilderness being maintained?

Monitoring Indicator(s)

Visibility is the only resource specifically designated as an AQRV by the Clean Air Act for all Class I areas. New pollutants should always be examined to ensure that new threats are identified as soon as possible.

The Forest collects information on approximately 130 chemicals in air and precipitation. A small subset selection of these chemicals are in this report as indicators. These indicators relate most directly to the monitoring questions and many have been studied for a very long time. Indicators for the monitoring question are:

- Precipitation acidity.
- Ozone concentration in the air.
- Lichen communities.
- Mercury concentration in fish.
- Nitrogen, phosphorus, and Chlorophyll a concentrations in lakes.
- Concentration and composition of fine particulates.
- Concentration of pesticides, PCPs in rain and lakes.

Monitoring Frequency

Collection on the monitoring information for the indicators and monitoring question occurs every one to five years.

Background & Driver(s)

This section addresses the following drivers from the Forest Plan, page 2-9:

- D-AQ-1: Air on the Forest is of high quality so that:
  - Ecosystems are not impaired by stressors originating in the air (for example, acid deposition, direct injury to vegetation by air pollutants, detrimental changes to soil chemistry, and mercury contamination of fish).
  - The health of visitors, residents, and employees is not impaired.
  - Visibility does not impair scenic quality.
  - Other air quality related values are not adversely affected
- D-AQ-2: New and modified industrial facilities do not degrade Forest resources or uses.
- O-AQ-1: Maintain the ambient air on the Forest within the National Ambient Air Quality Standards and the Minnesota Ambient Air Quality Standards.

The Clean Air Act regulates air quality in the U.S. This is done primarily through setting National Ambient Air Quality Standards for certain air pollutants. These standards apply across the U.S. Another section of the Clean Air Act (CAA) applies specifically to the BWCAW. The Clean Air Act classifies certain wilderness areas as "Class I." Class I areas are certain national parks and wildernesses managed by the National Park Service, U.S. Fish and Wildlife Service, and U.S. Forest Service that were of a certain minimum size (5,000 acres for wildernesses) in 1977 when the CAA was revised to add this section. By virtue of the date and size criteria, only some USFS wildernesses qualify as Class I. Non-Class I wildernesses are often referred to as Class II.

The Forest Service has an "affirmative responsibility" to protect air quality related values (AQRVs) of its Class I areas (see CFR 40 CFR 52.21(p)(2)). The AQRVs are defined as "A resource, as identified by the federal land manager for one or more Federal areas, that may be adversely affected by a change in air quality. The resource may include visibility or a specific scenic, cultural, physical, biological, ecological, or recreational resource identified by the FLM for a particular area" (FLAG 2010).

The SNF also has a responsibility under the Clean Air Act and other legal authorities (such as the Wilderness Act) to measure and understand the trends and impacts of air quality on the resources of the Forest. Impacts must then be communicated to the appropriate regulators (EPA, MPCA) so action can be taken to alleviate any adverse impacts.

The SNF monitors air pollution two ways. The first is by measuring the composition of the air and precipitation directly. The second is monitoring the effects of air pollution on other Forest resources.

Sources of Air and Precipitation Pollution

To understand the subsequent discussion, it is useful to have a general understanding of the dominant air pollutants and their sources.

Sulfur is important because it can contribute to acid rain, fine particulate matter formation (and therefore also visibility impairment), and facilitate the conversion of mercury into a form that can be incorporated into the food chain.

Power generation from coal is the dominant source of sulfur emissions. Regional- and national-scale sulfur emission control programs targeting coal-fired power plants nationwide (i.e. the Acid Rain Rule, which is a cap and trade program to control emissions of sulfur from power plants) help monitor the amount of sulfur emissions that are released into the atmosphere. The BWCAW has reduced sulfate in the air and precipitation that has had a positive effect on associated ecosystem characteristics (i.e., water quality and mercury levels in fish).

Nitrogen is another important pollutant and is present in nature in many forms. It can also contribute to acid rain and form fine particles that cause visibility impairment. A unique characteristic of nitrogen is that it is a fertilizer. However, if too much absorbs into an ecosystem, it can cause shifts in species of aquatic and/or terrestrial organisms away from those adapted to the naturally nutrient-poor conditions on most areas of the Forest.

Anything that burns any type of fuel is a nitrogen source. Motor vehicles are important sources. Ammonia from farming activities is also an important nitrogen source in the Midwest. Figure 5.1-1 below shows that total nitrogen deposition from the atmosphere peaks in the Midwest, primarily due to agricultural sources. This peak is near enough to the Forest to cause concern about potential transport.

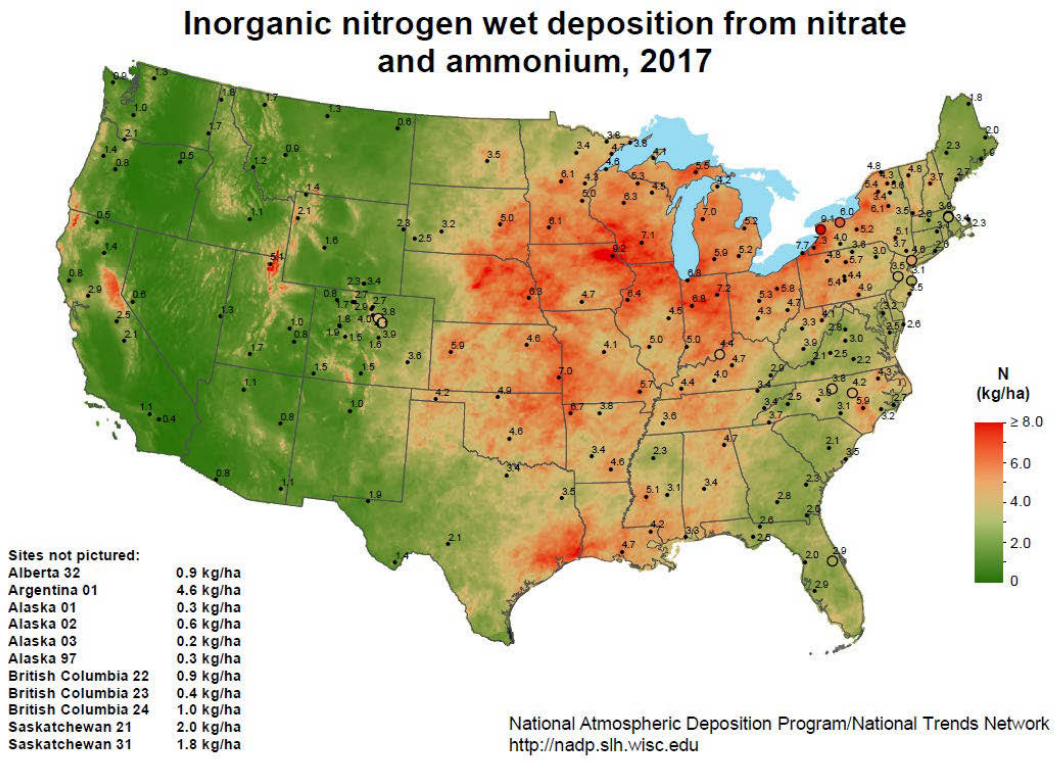


Figure 5.1-1. Inorganic nitrogen wet deposition from nitrate and ammonium, 2017

The Forest uses air quality models to determine the location of important sources of air pollution to the Forest. In 2012, the State of Minnesota submitted a plan to the Environmental Protection Agency (EPA) to improve visibility in the BWCAW and Voyagers NP. That plan shows that for haze in the BWCAW, Minnesota sources is the largest contributing State, accounting for about 28 percent of the total (table 5.1-1).

Table 5.1-1. Highest state contributions to light extinction in natural areas in the Great Lakes

State	BWCAW (%)	VNP (%)	Isle Royale (%)
Minnesota	28	31	13
Wisconsin	10	6	16
Illinois	6	3	8
Iowa	8	7	8
Missouri	6	4	5
North Dakota	6	13	4

(MPCA 2009 and 2012)

Monitoring Indicator: Precipitation Acidity

Results

Figure 5.1-2 shows precipitation acidity, as measured by pH, in northeastern Minnesota. The higher the pH, the less acidic the precipitation is. The graph shows that precipitation acidity has been showing marked improvement after a flat period from 2003 to 2008. Before 2003, another period of improvement was evident (starting in 1998). This trend is due to reductions in industrial air emissions of sulfur dioxide required by Federal and State regulations, especially from coal-fired power plants.

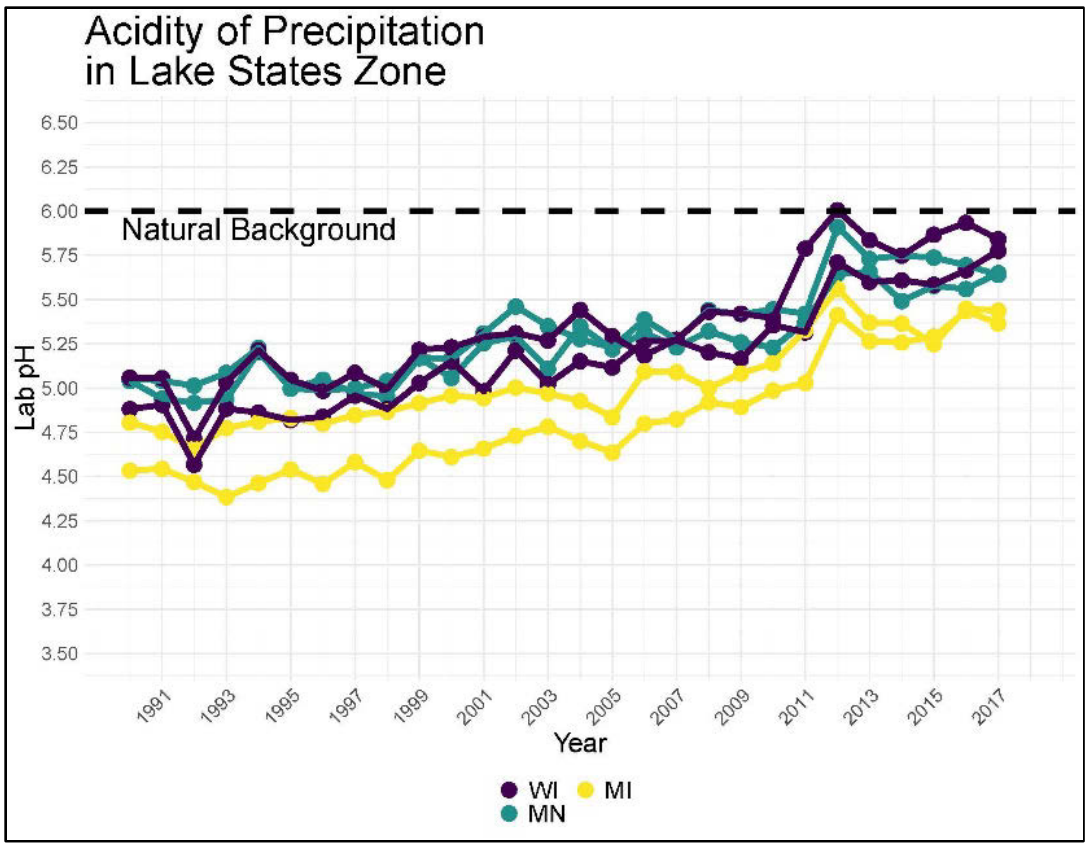


Figure 5.1-2. Acidity of precipitation in Lake States zone

Note: A lower pH value indicates an increase in acidity.

Scientists believe that natural precipitation pH is around 5.6 to 6. Figure 5.1-2 shows that the two Minnesota sites- Marcell (near Grand Rapids), Fernberg (BWCAW) - have been within this range recently. Sites near the shore of Lake Superior are consistently more acidic (for example Wolf Ridge and Hovland).

Sulfur is the dominant chemical in precipitation that causes acidity. The sites listed above also monitor atmospheric deposition of sulfur. Figure 5.1-3 displays the trends below.

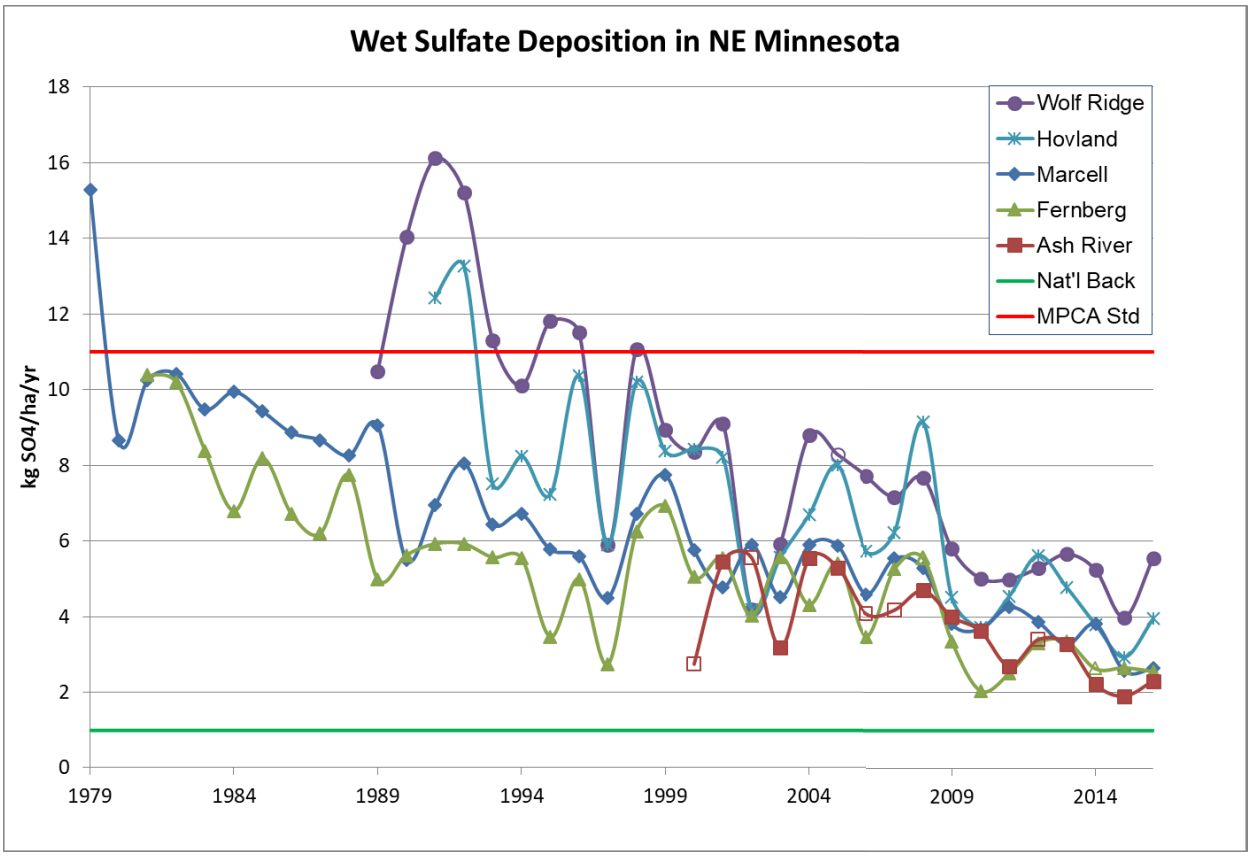


Figure 5.1-3. Sulphur in precipitation in the Lakes States

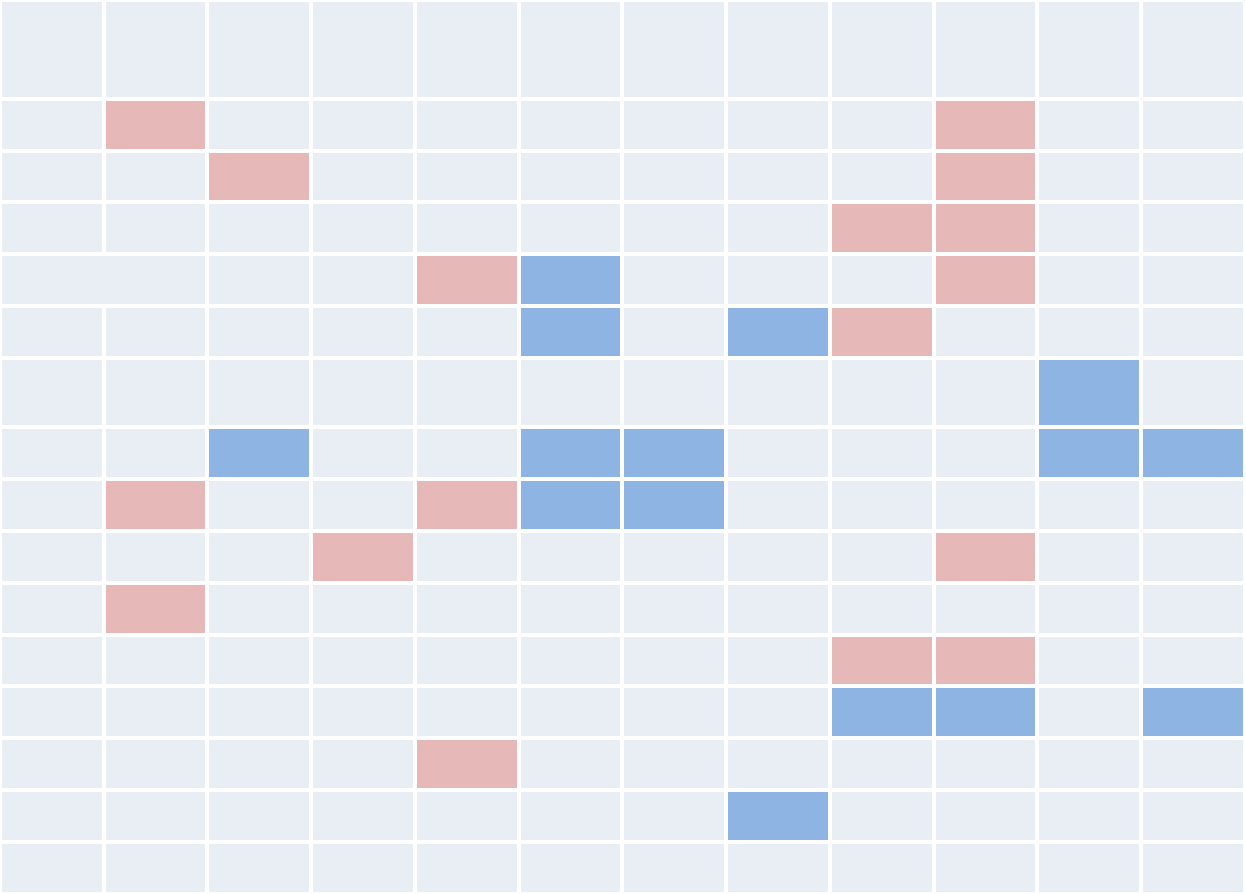
Note: The red line is the Minnesota wet sulfate standard to address acid rain impacts

The trends in sulfate deposition strongly track national power plant sulfur emission trends. This shows the influence of widely dispersed sources on precipitation quality on the Forest.

Sulfur in precipitation ends up in lakes on the Forest. A recent summary analysis (table 5.1-2) shows that six lakes had statistically significant declining sulfate trends over the last ten years.

The likelihood that acidic precipitation will negatively affect the ecosystem depends on the chemical capacity of the soils to neutralize the precipitation and the sensitivity of the local waterbodies based on their hydrological setting (Webster 1995). The existence of natural organic acids from wetlands is thought to play a role in mitigating acid precipitation (EPA 2009; MPCA 1997). The Forest measures the chemistry of acid-sensitive lakes to determine any adverse effects from acid precipitation or other pollutants from the air.

Table 5.1-2. Statistical analysis of trends in Superior NF Lake Dataset (McMurray 2015)



Increasing (blue) and decreasing (pink) trends from the Superior NF long-term dataset. The asterisk symbol represents at what p-value the significance is. *= <0.05, ** = <0.01, ***=<0.001. There were 15 lakes with long-term datasets and 28 possible variables to analyze.

Further information on these issues is in the monitoring and evaluation project files.

Discussion

Within the last ten years, routine monitoring of acid sensitive lakes on the Forest has shown that some experienced sporadic acidification. The reason for this is not clear but it is not due to acidic precipitation, since precipitation has been recovering (becoming less acidic, see figure 5.1-2) over this period. The Forest is currently participating in a multi-agency research project with Northern Research Station, the State of Minnesota, and UMD-NRRI to study the reasons for the acidification. Early indications are that climate change, and its effects on hydrological regimes (e.g. the timing and quantity of precipitation, the frequency of wet/dry cycles) may be important (Serediak 2014).

Monitoring Indicator: Ozone Concentration

Results and Discussion

Ozone found at ground level is an air pollutant and commonly referred to as smog. Ozone in the upper atmosphere protects life on earth from harmful ultraviolet radiation (known as the ozone layer). The section will discuss ground level ozone. Ozone forms in the lower atmosphere from other air pollutants, namely nitrogen oxides and volatile organic compounds (VOCs) in the presence of sunlight. Due to its sunlight and temperature dependence, ozone usually peaks in the

summer. Nitrogen oxides are generally the chemicals that limit ozone formation in rural forested areas since natural sources of VOCs from vegetation are usually in abundance. Warm temperatures lead to more ozone, so year-to-year variability in ozone levels results from differences in the average summer temperature. This temperature dependence makes ozone a pollutant that is particularly sensitive to climate change. The EPA regulates ozone, not only for harmful effects to humans but also because it can cause injury to plants.

The Forest has monitored ozone since the late 1970s. The hourly data converts to calculating different metrics. An eight-hour average is used to compare to health standards. Currently, all monitors near the Forest comply with the human health standard for ozone.

To assess the impacts of ozone to vegetation a weighted average metric is used (W126). The metric calculated for this report is the 12-hour W126 over the 3-month period (typically April through June). These months correspond to the period of highest ozone values. When EPA considered setting a vegetation standard in 2008 to protect plants, the lower end of the proposed standard was seven ppm-hrs. Assuming this level would protect the most sensitive plants on the Forest. Figure 5.1-4 shows that since 2007, ozone should not be adversely affecting vegetation on or near the Forest. Figure 5.1-5 shows that ozone has continued to be low.

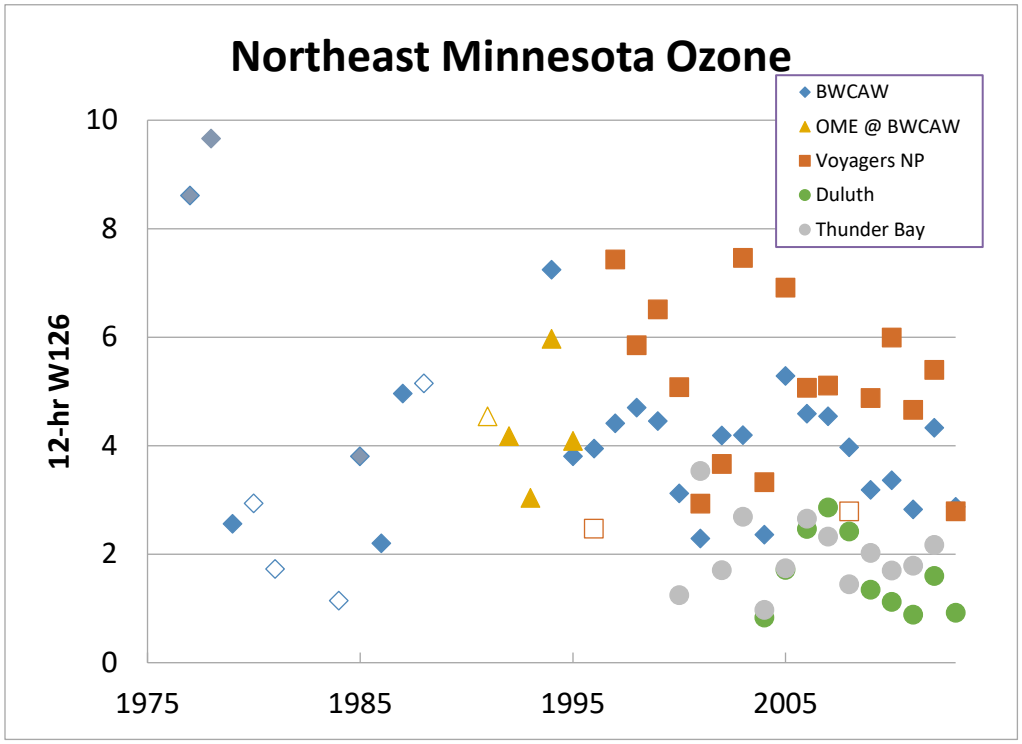


Figure 5.1-4. Northeast Minnesota ozone

NOTE From 1991 to 1995, the Province of Ontario ran an ozone monitor at the Fernberg site (BWCAW), which is "OME @ BWCAW" on the chart.

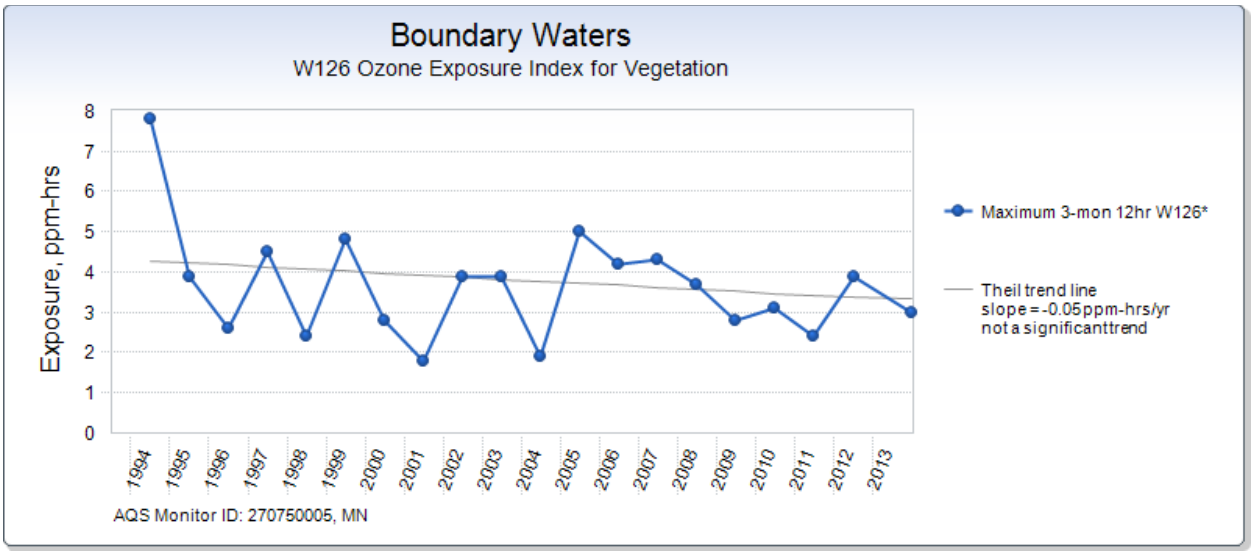


Figure 5.1-5. Ozone at the Boundary Waters

Credit: FED website: http://views.cira.colostate.edu/fed/

This conclusion also agrees with plant surveys done to assess potential ozone injury on sensitive vegetation. Ozone-caused injury on plants is distinctive and identifiable by trained individuals. From 1994 through around 2010, the Forest assessed ozone injury through the forest inventory and analysis (FIA); Phase 3 plots (USDA-FS, 2012). From 1994 – 2008, Minnesota obtained data from this program. During those years, the Forest evaluated over 28,000 plants on almost 500 plots statewide and documented only nine plant injuries.

Monitoring Indicator: Lichen Communities

Results and Discussion

Lichens are a group of nonvascular plants that are sensitive to air pollution and serve as indicators. They also act as accumulators of contaminants, and are easy to collect, preserve, and analyze.

A study conducted in the summer of 1986 determined the baseline lichen condition in the BWCAW (Wetmore 1987). The study collected around 2,500 species across the BWCAW that identified 369 species of lichen. The study described the flora as quite diverse and included species that are particularly sensitive to air pollution. The BWCAW did not display holes in the distribution of the sensitive species. Most species present in the region in a 1903 survey were also present in the 1986 study. In addition, an elemental analysis determined that no abnormal accumulations of air pollutants.

The 1986 study recommended periodic reanalysis of the elemental content of the lichens to check for changes over time. The Forest conducted these in 1992, 1997, and 2002. Over this period, the main trend noted was a decrease in lead due to the removal of lead from gasoline. The study identified no concerns over air pollution. The study discontinued sampling after the 2002 sampling season.

In 2017, lichen collection occurred again at 10 sites in the BWCAW. The report on this collection is forthcoming.

Monitoring Indicator: Mercury Concentrations in Fish

Results and Discussion

Humans

For many years, the Forest supported the statewide effort of collecting fish and analyzing them for mercury contamination by paying for sampling of additional numbers of lakes on the Forest. The State's most recent statewide mercury summary (MPCA 2017) found that mercury in precipitation has been decreasing at the BWCAW monitoring site. However, the statewide fish data displays evidence for a trend reversal from decreasing to increasing around 1990, potentially from watershed-related changes and not increases in deposition.

To achieve the necessary reductions of mercury in fish, Minnesota's Statewide Mercury Total Daily Maximum Load (TMDL) established a goal of a 93 percent reduction in mercury input from all human sources. Minnesota receives 90 percent of its mercury pollution from outside the State. Rapid economic growth in Asia and India since 1990 has contributed to increased global emissions of mercury, despite mercury emissions in North America and Europe reductions to half the amount since 1990. (Minnesota 2016)

Wildlife

The Forest is also concerned about the impacts of mercury in fish-eating wildlife. Efforts since the early 1990s have established the common loon as principal indicator of mercury availability for freshwater piscivores (an animal that feeds on fish).

Loon monitoring helps assess the impacts of mercury on wildlife. A study starting in 2005 to capture and sample loon blood and feathers for mercury analysis determined the lead content in the species.

Based on loon mercury samples, all the data was below adverse effect levels. Samples from the northwest part of the Forest tended to be the highest. All lead levels except one were at background levels. The one high value attributes to a loon ingesting a lead sinker. The loon likely died within two weeks from sampling. The SNF loon Hg levels averaged higher than statewide Minnesota levels but were lower than levels found in the eastern US (figure 5.1-6).

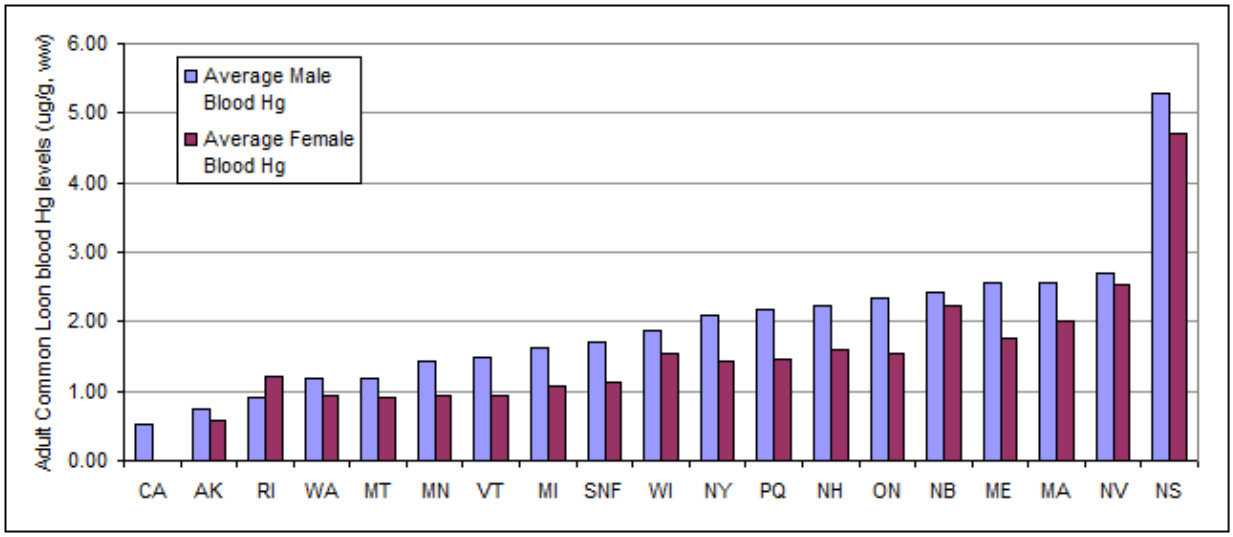


Figure 5.1-6. Adult blood Hg concentrations for common loons across North America

Monitoring Indicator: Nitrogen, Phosphorus, and Chlorophyll a concentrations in lakes

Results and Discussion

Nutrients are important because they control lake productivity levels and levels of biomass in the lakes. The more productive the lake is, the more algae growth. In the extreme case, an overabundance of algae will consume a significant amount of the oxygen in the water when it dies. This can adversely affect the fisheries in the lake. Even small changes in nutrients are important because, while they may not cause productivity changes in a lake, they can cause species of plankton to shift - especially in the nutrient poor lakes present on the Forest. Nutrients can get into a lake from soil runoff in the watershed and by direct deposits from the air.

Lake productivity can be measured a number of ways. The nutrients themselves – nitrogen and phosphorus - can be measured. Water clarity is another measurement tool. However, many Forest lakes are tea-stained due to organic carbon from the watershed, so this is not as useful compared to other areas of the country where water clarity can be directly tied to algal biomass and therefore also productivity. Other aquatic biomass measurements are other indicators used, such as using chlorophyll a or identifying the number of aquatic plankton species present. The Forest and partners measure many of these parameters.

Historical Perspective

To compare current lake conditions with pre-settlement conditions, sediment cores are used. Reconstructions were made forchloride, pH, color, and total phosphorus for lakes in Minnesota (Ramstack 2004). The lakes were stratified by ecoregion, with the Forest lakes falling in the northern lakes and forests (NLF) ecoregion.

Total phosphorus (TP) and clarity are indicators of changes in lake productivity. The study noted:

- The NLF lakes showed no systematic TP changes from 1800 to the present; about half the lakes showed modest declines in TP, whereas the others showed modest increases or no change.
- Although the NLF ecoregion is the most pristine in this study, there are local impacts such as recreational development and vegetation management activities, that have the potential to increase TP loading to these systems. However, these influences appear to have been relatively minor on average, as there has been very little change in the TP levels of NLF lakes since European settlement.
- The pre-settlement estimate of TP r 8-20 micrograms per liter. This compares well with current measurements

Current

The previous discussion indicated that overall, lakes on the Forest have changed little over the last 200 years in regards to productivity. Forest staff use data comparisons for lake water quality to compare Forest lakes with others in the region, State, and Nation.

Many parties take water samples using different methods and analyze them for different constituents to help answer many different questions. It is difficult to use the data from all these separate efforts together to understand the condition of all the Forest's lakes. The EPA has the responsibility to assess the health of the Nation's waters. They developed a statistically based survey for the Nation's lakes, (and separate surveys for rivers, wadeable streams, coastal waters,

and wetlands) on a rotating five-year cycle termed the National Lakes Assessment (NLA). Surveys were taken in 2007, 2012, and 2017.

The survey starts with a random draw of lakes generated by EPA to make statistically valid statements about the condition of the Nation's lakes in each ecoregion. In 2007, the State of Minnesota added nine lakes to its original draw so that it could make a statistically valid statement about the condition of all the lakes in Minnesota. In 2012, Minnesota added 100 lakes to EPAs initial random draw so it could go further and assess each of the three ecoregions in Minnesota separately (figures 5.1-7 and 5.1-8).

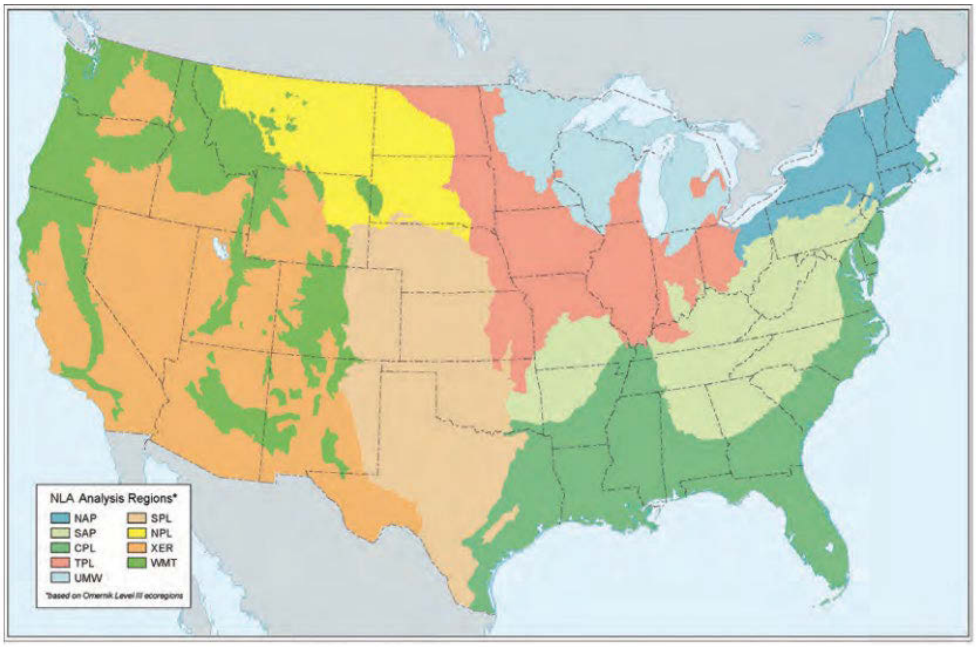


Figure 5.1-7. Ecoregions used as part of EPAs National Lake Assessment (EPA 2009)

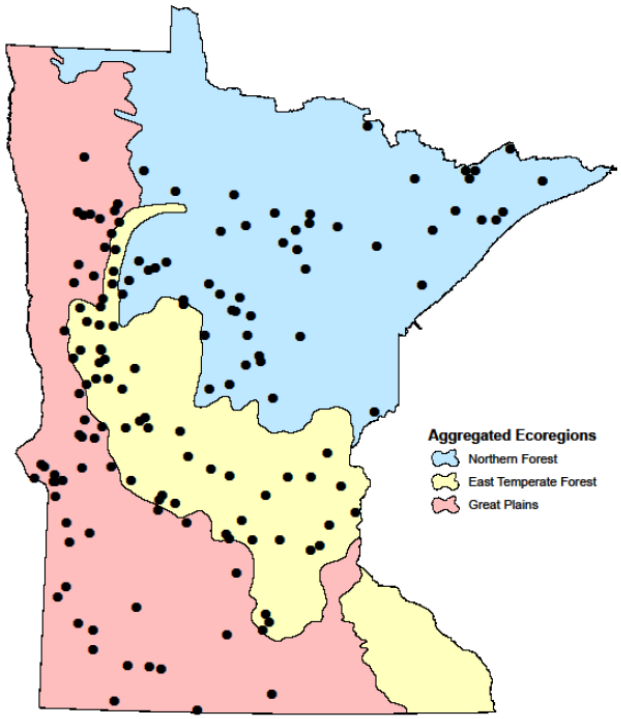


Figure 5.1-8. Minnesota's 2012 NLA lakes and level 3 ecoregion map (MPCA 2016)

Lake trophic state was one parameter that the NLA addressed. It is synonymous with lake productivity. The indicator for trophic state in the NLA is chlorophyll a concentration. Nutrients area also important to productivity so this data (total phosphorus – TP, and total nitrogen - TN) (table 5.1-3).

Table 5.1-3. EPA national lake assessment—productivity-related parameters

		Nation '07 (%)	Upper Midwest '07 (%)	Minn. '07 (%)	Nation '12	Minn. '12 (%)	MN North. Forests '12 (%)	SNF Small Lakes '01 -'16 (%)
Chlor a	oligo-trophic	13	9	4	TBD[1]	3	9	18
	meso-trophic	37	54	47	TBD	34	41	72
	eutrophic	30	26	25	TBD	30	34	10
	hyper-eutrophic	20	10	24	TBD	34	16	0
TP	Good	NA[2]	66	39	NA	44	77	74
	Fair	NA	25	24	NA	24	23	25
	Poor	NA	9	37	NA	32	0	1

		Nation '07 (%)	Upper Midwest '07 (%)	Minn. '07 (%)	Nation '12	Minn. '12 (%)	MN North. Forests '12 (%)	SNF Small Lakes '01 -'16 (%)
TN	Good	NA	59	43	NA	17	38	86
	Fair	NA	33	23	NA	27	49	13
	Poor	NA	8	34	NA	57	13	1
>100 ha				42		23	17	6
50-100 ha				26		14	8	9
20-50 ha				18		25	27	8
10-20 ha				6		16	20	8
4-10 ha				8		6	18	8
<4 ha				0		16	10	0

NOTES for table: The national cutoffs set by EPA for chlorophyll a are oligotrophic <2 ug/L, mesotrophic > 2-7 ug/L, eutrophic >7 top 30). Nutrient data was categorized per ecoregion with different qualitative cutpoints (e.g. good, fair, and poor) in each ecoregion. For Upper Midwest, ecoregion good/fair cutoffs were 16.5 ug/L for TP and 674 ug/L for TN and fair/poor cutoffs were 36 ug/L for TP and 1174 ug/L for TN.

NOTE: the minimum lake size was dropped from 4 to 1 ha between the 2007 and 2012 NLA resulting in a different target population of lakes 1-TBD is to be determined. 2-NA is not available

The data in table 5.1-3 allows for a comparison between lakes on different geographic scales. As seen in figures 5.1-7 and 5.1-8, the State splits the upper Midwest ecoregion in Minnesota into two ecoregions: the northern forest (NF) and eastern temperate forest.

The trophic state of a lake is usually described as being in one of four states:

- Oligotrophic (least productive).
- Mesotrophic.
- Eutrophic.
- Hypereutrophic (most productive).

As the data set are narrowed down from nationwide to the upper Midwest ecoregion or state, then to Minnesota's northern forest ecoregion, and finally to lakes on the Forest, the lakes become less productive and the level of nutrients also decrease. The lakes on the Forest are the least impaired in the State and are less productive than the entire upper Midwest ecoregion measured in 2007.

As mentioned, elevated trophic state can lead to algae blooms. Using previously established Chlorophyll a thresholds: less than10 µg/L "no bloom," 10-20 "mild bloom" and greater than 20 µg/L "nuisance bloom," the NLA data provide an indication as to the extent and magnitude of summer algal blooms (MPCA 2016). Either no blooms or mild blooms characterized eighty-five percent of national forest region lakes. For the Forest's lake data set, 98 percent of the measurements qualify as no blooms (two percent are in the mild bloom criteria).

Total nitrogen (TN) to total phosphorus (TP) ratios have been used for estimating which nutrient may be limiting algal production (i.e. lake productivity) and provides a relative comparison among TP and TN supply. Ratios less than10:1 indicate potential for "N-limitation" while greater than 17:1 indicates the potential for "P-limitation." Ratios in between suggest that either P or N could be limiting. Minnesota's lakes are strongly P-limited with 78 percent being greater than17:1 (MPCA 2016). P limitation is most frequent in the national forest ecoregion of the State (85 percent), with even greater occurrence in the SNF lakes (96 percent). This means that additions of phosphorus would be expected to have a larger increase in lake productivity than additions of nitrogen.

Nutrients deposited from the atmosphere

A recent article (Stoddard 2016) discussed nationwide increases in phosphorus seen in undisturbed streams and lakes with undisturbed watersheds (i.e. minimal agriculture, urban land uses, low-road density and low riparian disturbance) over the last 15 years. Two possible mechanisms that could explain this problem are increasing atmospheric deposition of phosphorus and/or an increased frequency of intense rainstorms washing more soil-bound phosphorus into waterbodies. The national atmospheric deposition (NADP) sites do not monitor for phosphorus deposition. Studies have shown that climate change increases the frequency of intense rainstorms.

The Minnesota Department of Agriculture has been monitoring rainfall for nutrients since 2008 and now has three sites in the farming areas of the state (MDA 2015). In 2014, they collected four precipitation samples at two of the sites. Nitrogen was not detected but total phosphorus was measured as high as (0.021mg/L), which is at about the 90th percentile of values measured in SNF lakes. What level of phosphorus deposition occurs over the Forest is an interesting unknown at this time.

Monitoring Indicator: Concentration and Composition of Fine Particulates

Results and Discussion

Fine particulate matter in the air absorbing and scattering light causes visibility impairment. Different chemicals scatter light differently, with some being more efficient than other chemicals. Sulfate causes the largest portion of fine particulate matter, resulting in regional haze in the BWCAW (figure 5.1-9). Similar to the precipitation chemistry data, sulfur in fine particulates has also decreased due to local and national regulations on coal-fired power plants. This has resulted in clearer skies over the BWCAW

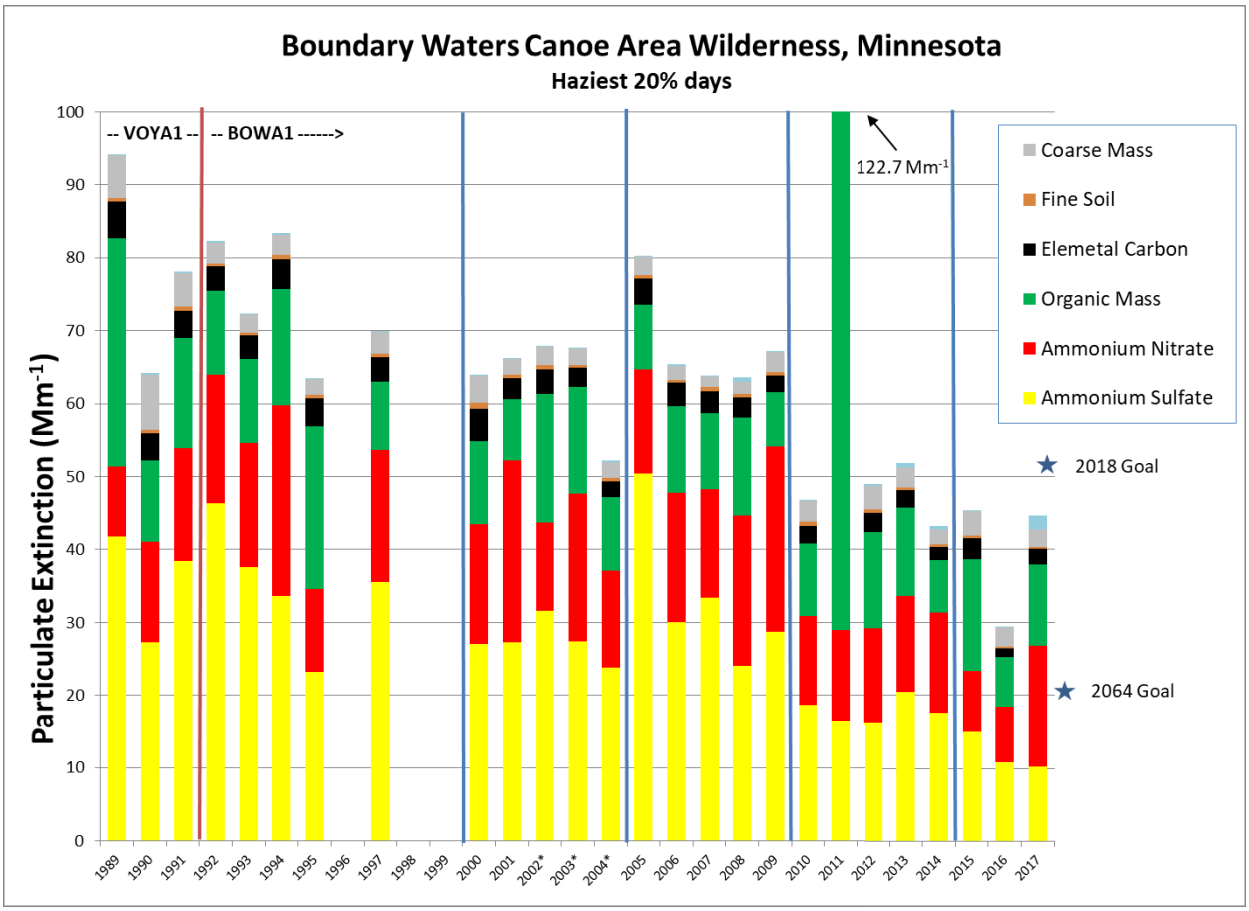


Figure 5.1-9. Composition of fine particulate matter in the BWCAW and Voyageurs National Park (1)

NOTE: The large spike in organic mass in 2011 is due to smoke from the Pagami Fire.

The regional haze rule aims to improve visibility on the most impaired days and to maintain the clearest days. All states must submit 10-year plans outlining their steps for improving visibility in Class I areas, within not only its state but also others. In 2012, the MPCA submitted its first 10-year plan. That plan is applicable through 2018 (like most states, it was submitted late). Work on the plan for the next 10 years is now underway. Visibility monitoring at the Forest's air monitoring site at Fernberg will be critical going forward since continued use will help determine whether the MPCA's plan is achieving its goal.

Monitoring Indicator: Concentration of Pesticides, Personal Care Products (PCPs) in Rain and Lakes

Results and Discussion

Pesticides and Herbicides

Rain in the U.S. commonly contains pesticides and herbicides. Herbicides can become airborne by volatilization and entrainment on dust particles, and then dispersed over considerable distances (over 100 miles) by air currents for possible re-deposition in watersheds from their application (Goolsby 1997 in MDA 2014).

As a part of the 2012 National Lakes Assessment (NLA), studies analyzed lake water samples for pesticides and herbicides. The results detected nineteen different pesticide compounds, with

atrazine discovered most frequently in 67 percent of samples. All pesticide compound detections were herbicides. Pesticides and/or degradation compounds were detected in 85 percent of the samples collected. Pesticide detections were widespread and included lakes in nonagricultural areas of the State, however, lakes in agricultural areas of the State tended to have more compounds detected at higher concentrations. Atmospheric deposition of pesticides was suspected as the primary transport mechanism in non-agricultural areas. All pesticide detections were well below established state water quality standards or United States Environmental Protection Agency (USEPA) reference values. (MDA 2014)

Pharmaceuticals and Personal Care Products (PPCPs)

The 2012 NLA also analyzed lake samples for PPCPs. The lakes sampled contained a variety of pharmaceuticals, personal care products, or other unregulated contaminants, regardless of the surrounding shoreline development in this study or history of exposure to treated wastewater effluent. The presence of cocaine and the appearance of amitriptyline, carbadox, and other pharmaceuticals in these lakes are difficult to understand. Moreover, there is no consistent pattern distribution of these chemicals in the lakes included in the study. Chemicals in trace amounts can enter water in several ways, as reported in these studies. The association with fine particulates and the subsequent deposition of these airborne particles appears to be a feasible mechanism for the chemical appearance in more remote Minnesota lakes. It is not clear what affect most of these contaminants might have on fish and wildlife, or on human health at the low concentrations observed (MPCA 2013)

Other Bioaccumulative Chemicals

Bioaccumulative chemicals do not break down to simpler substances, so they can be very long-lived in the environment. In addition to mercury, other bioaccumulative chemicals include industrial by-products like polychlorinated biphenyls (PCBs), and emerging chemicals such as flame retardants for fabrics (polybrominated diphenyl ethers - PBDEs) and stain repellents (perfluorinated chemicals - PFCs).

Air Toxics

Air toxics are a class of air pollutants that can affect ecosystems and are an emerging concern. There are 188 air toxics listed by USEPA (Air Toxics). These pollutants do not have standards but rather health benchmarks for guidelines and non-enforceable standards. These include certain organic and metallic chemicals, including mercury as discussed above. In 2010, the SNF collaborated with the MPCA to monitor for 74 of these chemicals at Fernberg. The Fernberg values were statistically at or below the statewide average for all but seven of the chemicals. Only one, formaldehyde, was above a health benchmark (MPCA 2014). This compares well with a previous statewide study done by MPCA from 1996-2001 in 35 sites statewide. Of the 73 chemicals collected and analyzed in that study, four were above MPCA approved inhalation health benchmarks at one or more sites, namely: formaldehyde, benzene, carbon tetrachloride, and ethylene dibromide. The concentrations of the later three subsequently dropped below health benchmarks. The Twin Cities area tended to be higher in concentration for many pollutants, due to the region's population size and more emission sources. Many of the pollutants had at least a partial correlation with population. While this holds true generally, population cannot explain all the differences between sites. Motor vehicles emitted many of the detected pollutants from cities and townships with increased populations.

5.1.2 Air Quality Effects Monitoring Question #2

To what extent is Forest management contributing or responding to air quality effects on ecosystems, human health or human enjoyment?

Monitoring Indicator(s)

The indicators used for this question are

- Fine particulates in air.
- Mercury in the burned watershed.

The primary management activity monitored for impacts to air quality is prescribed fire smoke. Since 2001, portable smoke monitoring equipment has measured the fine particulates due to smoke. In addition, ground and satellite photos monitor smoke impacts.

Monitoring Frequency

The Forest collects monitoring information for the indicators related to the monitoring question every one to five years.

Background & Driver(s)

At this time, SNF management activities represent a very small source to the Forest's annual air pollutant concentrations. Large prescribed burning projects can affect air quality but for only a short time.

This section addresses the following direction of the Forest Plan for air quality driving the monitoring question.

- D-AQ-3: Air emissions resulting from national forest management actions do not degrade natural resources or uses of the Forest.
- S-AQ-1 Prescribed burning activities on the national forest will only be conducted if they comply with requirements of the most current Minnesota Smoke Management Plan.

Monitoring Indicator: Fine Particulates in Air

Results and Discussion

Particulate matter is classified by size. The smallest size, known as fine particulate matter ($PM_{2.5}$), is the most dangerous because it can get deep in the lungs, causing both lung and heart problems.

The EPA health standard for fine particulate matter is 35 micrograms per cubic meter (ug/m^3) on a daily average basis, and 12 on an annual average basis. Figures 5.1-10 and 5.1-11 show that all locations in Minnesota are below both forms of the standard. They also show that the cleanest air is in northeastern Minnesota (see Ely, Virginia, and Duluth sites).

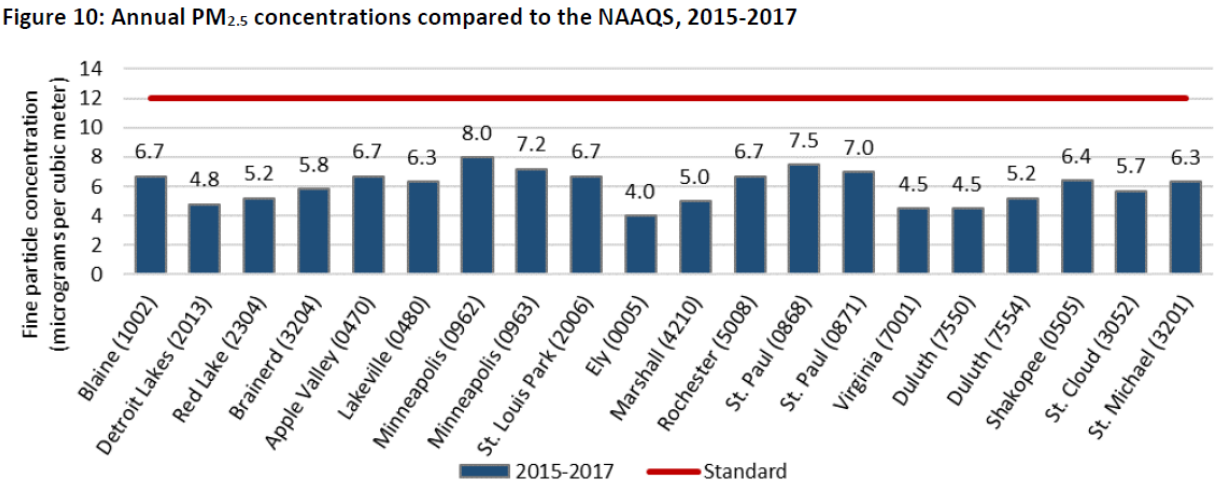


Figure 5.1-10. Annual fine particulate matter concentrations in Minnesota (MPCA 2019) (2)

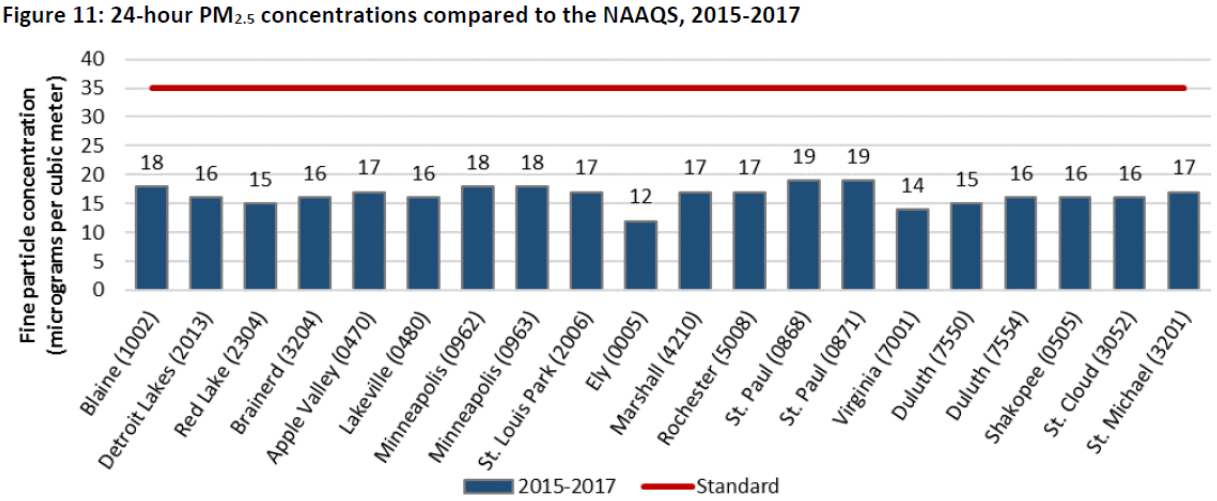


Figure 5.1-11. Daily fine particulate matter concentrations in Minnesota (MPCA 2019) (2)

Additional fine particulate data gathered by the Class I visibility monitors included in figure 5.1-12. The BWCAW data is from the Fernberg site. A general decrease is visible across all sites.

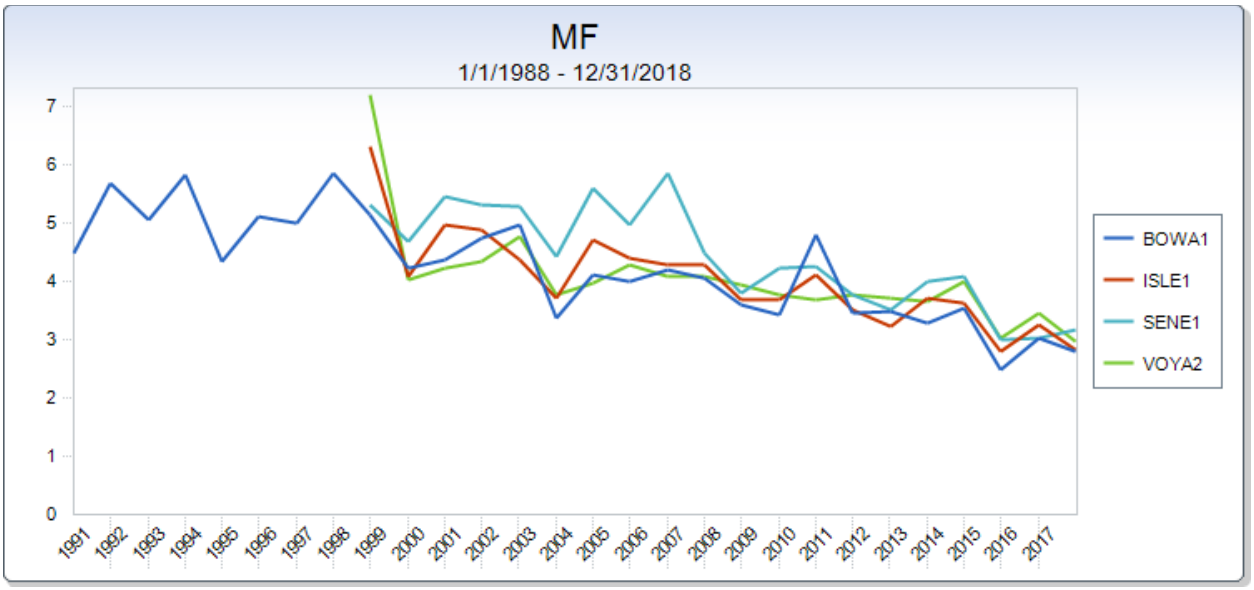


Figure 5.1-12. Fine particulate matter in natural areas of the Great Lakes (2)

NOTE: The high value at the BWCAW in 2011 is due to smoke from the Pagami Fire that was adjacent to the air monitor at the BWCAW.

Previous monitoring reports (last M&E report) have shown that while concentrations can be high in certain locations near the fire, prescribed fires can manage smoke to avoid sensitive areas. Smoke impacts from prescribed fires are short-lived, usually lasting only one or two days. The Forest has also shown ways to manage the smoke to avoid affecting sensitive receptors. The Minnesota state smoke management plan (SMP) contains the necessary measures to mitigate smoke impacts in Minnesota. All Forest burns follow the SMP.

Answering the monitoring question "whether air emissions from Forest management activities are *degrading* natural resources of uses on the Forest" requires a definition of the word "degrade." Regarding how smoke from prescribed fire could "degrade," it is important to consider from what baseline we should judge whether air quality is degraded. Historically fire was always present in the Forest (Heinselman 1996). Before European settlement, Native Americans used fire (Johnson 2016) and lightning naturally started many other fires. It is important to realize that often if the Forest does not prescribe burn an area, it is more likely to eventually burn in a wildfire that will be drier, consume more fuel, and generate more smoke (and air pollutants such as mercury). Judging whether smoky air degrades natural resources is a value-laden task. Thus, the Forest has shown:

- EPA health standards in the area are not exceeding.
- Particulates have been declining over time.
- Visibility has been improving.

From those perspectives, air quality is not degrading.

Monitoring Indicator: Mercury in the Burned Watershed

Results and Discussion

In 2004, the Forest began a study to understand how wildland fire effects the mercury cycle. The study has published numerous papers (Wickman2018), and included an investigation of wildland fire (both wildfires and prescribed fire) impacts on mercury levels in fish. A summary follows.

Previous studies have conclusively shown that:

- Mercury in our fish originates in the air.
- Upland areas hold a large amount of mercury that transports to aquatic environments and converts from an inert form to an organic form. From there, it that can enter the food chain through the process of methylation.
- The land holds a legacy of mercury deposited over decades - especially soils rich in organic matter.
- Land disturbance (such as wildland fire) can deliver mercury to fish in downstream sites.
- A positive relationship between watershed soil mercury and fish mercury in our watersheds before any recent fires occurred.
- During a fire, mercury in upland sites will leave the site in one of two main ways: either with the smoke or washed away later due to enhanced erosion post-fire.
- As fires grown in intensity, more mercury releases in smoke and less mercury remains in the soil afterwards.
- A stand-replacing fire can eliminate most mercury from the soil.
- Some mercury that leaves a site in the smoke deposits near the burn, while much of it will leave the site and enter the global atmospheric pool.
- Wildland fire-related mercury deposition measured around 30-40 percent of the annual deposition near fires.
- Over nine years, no impact for mercury in fish or changes in lake productivity in on BWCAW watershed from low- to moderate-severity wildland fires (one prescribed, one wild) has occurred. The effect of a high severity fire remains to be tested.
- Mercury found in fish and lake chemistry correlated more with climate and lake water levels than fires.

Across Minnesota and the U.S., air deposition is the main source of mercury to watersheds on the SNF. The MPCA has developed a total maximum daily load (TMDL) plan to reduce mercury in fish in the State (MPCA 2011). The MPCA estimates that 90 percent of the mercury deposition in the State comes from outside the State. However, the plan targets reductions in air emissions of mercury from Minnesota sources. The plan did not find any activities related to SNF management that required reduction. Moreover, fish in the St Louis River watershed have such high mercury levels that the State TMDL does not apply to it and utilizes a separate plan for that location.

Summary of Monitoring Findings

Modeling studies have shown the effects to the Forest's background air quality by broad categories of air emission sources, with about 75 percent from states and regions outside Minnesota. The data show that for northern Minnesota:

- Precipitation acidity has shown marked improvement after 2008. This trend is due to reductions in industrial air emissions of sulfur dioxide required by Federal and State regulations, especially from coal-fired power plants. The sulfur reductions are displayed in the 30-year decline of sulfur content in precipitation and the declining concentrations of sulfur measured in lake water.
- Ozone is the primary air pollutant that can affect vegetation, and the Forest has measured it since the 1970s. Beginning in 2006, the concentration of ozone dropped below the threshold assumed to adversely affect vegetation. FIA plots from 1994-2008 confirmed that plants with ozone damage are extremely rare anywhere in MN.
- The mercury concentration in fish is still high enough to cause the Minnesota Department of Health to issue advice to limit consumption. Mercury in precipitation has declined at the Forest's air monitoring site, but after many years of decline, mercury in fish may be increasing. This is likely due to climate and watershed factors. The Forest measured the mercury content of loons in 2005 and found it to be below adverse impact levels.
- Lakes on the Forest are some of the cleanest in the eastern U.S., regarding nutrients. Studies indicate that water quality in these lakes is very similar to what existed during the pre-European settlement era. . Of concern is a recent paper indicating that the very cleanest lakes in the U.S. may be starting to see some increases in phosphorus in the last 15 years. Causes of this increase are unclear. In addition, lakes in the Lake States seem to be following the trend in lakes across the northern hemisphere of increased organic carbon (Corman 2018)
- Visibility has improved over the last ten years in the BWCAW and surrounding Class I areas. The primary driver for this is reducing sulfur emissions from power plants.
- Northern Minnesota is currently meeting EPA standards for the six primary air pollutants. The trend in fine particulate pollution has been downward at the Class I areas in the region.
- Monitoring done for about 74 of the 188 chemicals termed air toxics showed only one above health benchmarks on the Forest. The same was true statewide.
- The environmental effects of air pollution could change over the next 100 years due to climate change. One example is ozone formation, which ties intimately to temperature. Climate change is predicted to cause temperatures to increase anywhere from two to 10 degrees F by the end of the century (NRS 2014). The future could experience more ozone due to climate change, irrespective of any changes in air emissions that lead to ozone formation. More ozone could lead to more severe human health impacts and cause vegetation impacts to appear in this area.
- Another effect of climate change is more precipitation falling in larger events. This can cause more extreme wet-dry cycles that can lead to changes in biogeochemical cycles of wetlands and associated waterbodies. Specific chemicals involved include mercury, sulfur, and organic carbon. One thing this can lead to is increased acidity. Another potential climate effect is the increase in organic carbon noted in Minnesota lakes (Ramstack 2004) and across the glaciated regions of northern hemisphere (Monteith 2007), which can have

unforeseen consequences to within lake processes (Zwart 2016). This phenomenon is the subject of an ongoing study that took place on the Chequamegon-Nicollet NF (Corman 2015).

Recommendations

Prescribed Burning

Smoke management practices should continue with specific activities as requested by fire managers. Key activities include pre-burn modeling, day-of-the-burn modeling, monitoring, and public dialog.

Following wildland fire, it is a good idea to mitigate soil erosion. Mercury is closely associated with carbon, so keeping soil out of surface water bodies is important. The ultimate solution to the problem is to a global reduction of mercury emissions.

The Value of Long-Term Monitoring

Because the problems of the future are unknown, the maintenance of long-term chemical monitoring of air and water is critical. The recent acidification of some acid sensitive lakes on the Forest was completely unexpected; however, the Forest has been actively monitoring long-term water quality and identified the concern in a short period. The Superior recommends the establishment of an annual monitoring program of five long-term monitoring and mercury study lakes, to continue the monitoring that began in 2012.

Research

Research is critical to help answer complicated questions that affect our management efforts. There are currently ongoing collaborations with researchers to address the following questions:

- Are acid sensitive lakes becoming more acidic due to the effect of climate change on hydrology?
- How is the increase in organic carbon affecting lake chemistry and biological processes?
- How can the Forest better predict the lake breeze when planning prescribed fires?
- What are the thresholds of adverse effects from atmospheric deposition to ecosystem components (e.g. trees, herbs, lichen, and water quality)?

References

Corman J. 2015. "Environmental change and the lakes of the Chequamegon-Nicolet National Forest", USFS Lake States Soil, Water, Air and Aquatics sub regional workshop, Ashland, WI, 4/26/16

Corman, J. R., B. L. Bertolet, N. J. Casson, S. D. Sebestyen, R. K. Kolka, and E. H. Stanley. 2018. "Nitrogen and Phosphorus Loads to Temperate Seepage Lakes Associated With Allochthonous Dissolved Organic Carbon Loads." Geophysical Research Letters 45, no. 11 (June 16, 2018): 5481–90. https://doi.org/10.1029/2018GL077219.

Evers DC, Siegel L, Goodale MW. 2008. Spatial and temporal trends in biotic mercury concentrations in the Superior National Forest, Minnesota. Report BRI 2008-01 submitted to the Superior National Forest. BioDiversity Research Institute, Gorham, ME.

Goolsby, D. 1997. Herbicides and Their Metabolites in Rainfall: Origin, Transport, and Deposition Patterns across the Midwestern and Northeastern United States, 1990-1991. Washington, D.C.: American Chemical Society. Print.

Heinselman, M. 1996. The Boundary Waters Wilderness Ecosystem. University of Minnesota Press, 334 pgs.

Johnson, Lane B., and Kurt F. Kipfmueller. 2016. "A Fire History Derived from *Pinus Resinosa Ait*. for the Islands of Eastern Lac La Croix, Minnesota, USA." Ecological Applications 26 (4): 1030–46. https://doi.org/10.1890/15-1151.

Minnesota Department of Agriculture. 2014. Pesticides in MN Lakes – 2012 NLA, 1/2014 36 pgs. http://www.mda.state.mn.us/chemicals/pesticides/~/media/Files/chemicals/maace/2012pesticideslakes.pdf

Minnesota Department of Agriculture. 2015. 2014 Water Quality Monitoring Report. June 2015

Minnesota Pollution Control Agency. 1997. Temporal Trends and Spatial Patterns in Acid-Base Chemistry for Selected Minnesota Lakes, E&S Environmental Chemistry, Inc. Corvallis, OR, March 1997

Minnesota Pollution Control Agency. 2005. Minnesota Statewide Air Toxics Monitoring Study (1996-2001) Final Report https://www.pca.state.mn.us/sites/default/files/aq1-29.pdf

Minnesota Pollution Control Agency. 2009. Regional Haze State Implementation Plan December 2009, https://www.pca.state.mn.us/sites/default/files/aq-sip2-12.pdf

Minnesota Pollution Control Agency. 2013. Pharmaceuticals and Endocrine Active Chemicals in Minnesota Lakes • May 2013 MPCA, 47 pages https://www.pca.state.mn.us/sites/default/files/tdr-g1-16.pdf

Minnesota Pollution Control Agency. 2014 Ely Air Monitoring Study - Air monitoring results for nitrogen dioxide, sulfur dioxide, and air toxics https://www.pca.state.mn.us/sites/default/files/aq10-11.pdf

Minnesota Pollution Control Agency. 2015, Annual Air Monitoring Network Plan for Minnesota 2016, October 2015, https://www.pca.state.mn.us/sites/default/files/aq10-13a.pdf
Minnesota Pollution Control Agency. 2016. Clean Water Fund Performance Report, A

report of Clean Water Funds invested, actions taken and outcomes achieved. Feb 2016, https://www.pca.state.mn.us/sites/default/files/lrp-f-3sy16.pdf

Minnesota Pollution Control Agency. 2016. National Lakes Assessment 2012 – Water Chemistry, lake morphometry, and watershed characteristics of Minnesota's 2012 NLA lakes. January 2016 https://www.pca.state.mn.us/sites/default/files/wq-nlap1-14.pdf

Monteith DT, Stoddard JL, Evans CD, de Wit HA, Forsius M, Høga°sen T, Wilander A, Skjelkva°le BL, Jeffries DS, Vuorenmaa J, Keller B, Kopa´cek J, and VeselyJ. 2007. Dissolved organic carbon trends resulting from changes in atmospheric deposition chemistry. Nature: Vol 450:537-540

National Atmospheric Deposition Program. 2016. Inorganic Nitrogen Deposition Map. Accessed 6/15/16. http://nadp.isws.illinois.edu/maplib/pdf/2014/N_dep_2014.pdf

Northern Research Station, USDA Forest Service. 2014. Minnesota Forest Ecosystem Vulnerability Assessment and Synthesis: a report from the Northwoods Climate Changes Response Framework Project. GTR NRS-133. May 2014, 228 pgs

Ramstack JM, Fritz SC, Engstrom DR. 2004. Twentieth century water quality trends in Minnesota lakes compared with presettlement variability. Can. J. Fish. Aquat. Sci. 61: 561–576

Stoddard JL, Van Sickle J, Herlihy AT, Brahney J, Paulsen S, Peck DV, Mitchell R, Pollard AI. 2016. Continental-Scale Increase in Lake and Stream Phosphorus: Are Oligotrophic Systems Disappearing in the United States? Environ. Sci. Technol. 2016, 50, 3409−3415

U.S. Environmental Protection Agency (USEPA). 2009. National Lakes Assessment: A Collaborative Survey of the Nation's Lakes. EPA 841-R-09-001. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C.

Zwart JA, Craig N, Kelly PT, Sebestyen SD, Solomon CT, Weidel BC and Jones SE. 2016. Metabolic and physiochemical responses to a whole-lake experimental increase in dissolved organic carbon in a north-temperate lake. Limnol. Oceanogr. 61: 723–734. doi:10.1002/lno.10248

5.2 Botany: Regional Forester Sensitive Species (RFSS) Plants

The Superior National Forest has identified plant and animal species as regional forest sensitive species (RFSS). For the time covered by this report, there were 58 RFSS plants. This section describes progress in meeting Forest Plan conservation objectives for these rare plants. Midway through 2017, the Forest updated the RFSS plant list; the next monitoring period will consider the new suite of plants.

Population Trend

Unlike RFSS animals, RFSS plants do not move and many of them use specialized microhabitats such as marshes, non-forested peatlands, and rock outcrops. It is difficult to measure the abundance of some of these types of habitats using typical forest stand data. The effects of forest management on these species can be difficult to measure, too. This section summarizes these monitoring efforts.

5.2.1 Conservation of Sensitive Species Monitoring Question:

To what extent is Forest management contributing to the conservation of sensitive species and moving toward short- term (10-20 years) and long-term (100 years) objectives for their habitat conditions?

This monitoring question is appropriate because there is concern with the continued viability of these species within the planning area. Forest Plan direction that drives this monitoring question is O-WL-18: Maintain, protect, or improve habitat for all sensitive species, and O-WL-30: Enhance or restore high quality habitat on a minimum of 20 known sites of sensitive plants. By considering RFSS plant population trends, we have a way of assessing how Forest management is contributing to the short- and long-term conservation of RFSS plants.

The Forest evaluates this monitoring question against indicators at two scales. For RFSS plants that are habitat generalists, a coarse filter indicator (acres of habitat) is used. For RFSS plants that are habitat specialists, a fine filter indicator (numbers of populations) is used. A third indicator (number of RFSS plant habitat improvement projects) applies at both scales. These indicators are appropriate because they are relatively easy to measure and cover two different but meaningful biological scales.

Coarse filter measurements of habitat use of management indicator habitats (MIH) aids in representing the amount of habitat available for the RFSS plants that are habitat generalists. Coarse filter monitoring is appropriate for 23 of the RFSS plants; these species use either forested wetlands or upland forests as their habitat. The Superior measures forested habitats during the process of forest vegetation inventory and summarizes them by MIH. The MIH data derives from the Forest Service Vegetation (FS Veg) database. Specific forest type and the project file contains the forest age-class indicators for these RFSS plants (USDA Forest Service 2016a).

Fine filter monitoring is most appropriate for the RFSS plants that do not have forest type indicators that allow for meaningful monitoring. These species use habitats such as cliffs or rock outcrops, marshes, fens, fluctuating shorelines, and other specialized habitats that are not readily captured in forest inventory data and do not change much over time. The Minnesota Department of Natural Resources (MN DNR) uses a rare feature database to track number of populations of RFSS plants over time. The Superior National Forest receives annual updates from this database

from the MN DNR. The data summarizes the number of different RFSS plant population occurrences for 2004 and 2017 (USDA Forest Service 2017).

Results

Coarse Filter

For the suite of RFSS plants that rely on mature lowland forest habitats, MIH analysis shows that suitable habitat for these species is abundant on the Forest and that it has increased slightly in the last ten years (USDA Forest Service 2016a). For the suite of RFSS plants that rely on mature northern hardwood forests, MIH analysis shows that suitable habitat for these species is abundant within the Sugar Maple Landscape Ecosystem and that it has increased slightly in the last ten years (USDA Forest Service 2016a). A few RFSS plants, like barren strawberry, Canada yew, and Canada ricegrass, that use a variety of young-to-mature forested habitats and seem to be habitat generalists, the abundance and distribution of habitat for these species appears to be adequate as well (USDA Forest Service 2016a).

Fine Filter

Analysis of RFSS plant occurrence data from the MN DNR rare feature database shows the numbers of populations tend to be stable, or some increasing, over the last ten years (USDA Forest Service 2017). This is primarily due to increased search effort that has detected new occurrences of these species over time. This analysis assumes that the populations of these RFSS plants still exist, and Forest staff test this assumption during midlevel analysis when visiting existing populations of RFSS plants to see if they are present or absent. Mid-levels assessments over the last ten years have demonstrated that known RFSS plant populations can generally be re-found and are still present. However, when a known RFSS plant is not re-found, it is difficult to know whether it is truly gone or simply missed due to poor search effort or poor information regarding exact location (common problem for older GPS-recorded locations). Using the MN DNR rare feature database as a tool for fine filter analysis of RFSS plant abundance can identify species that may have viability concerns.

Over the last ten years, the Forest has implemented thirteen projects for RFSS plant habitat improvement, and ten of those are complete (USDA Forest Service 2016b). These projects range from removing encroaching brush using hand tools or prescribed fire to keep RFSS *Botrychium* species habitats open, to replacing culverts, and improving hydrologic conditions for aquatic RFSS plants. These projects have been successful, with the exception of one site where reed canary grass has encroached to the extent that it is threatening to exclude the RFSS *Botrychium* species that occur at the site.

Analysis

The results suggest that the Forest is meeting Forest Plan objectives for RFSS plants over the last ten years. In the time of the Forest Plan, the expected conditions analyzed in the Forest Plan biological evaluation (BE) are consistent with the current conditions, and viability conclusions made in the Forest Plan BE are still valid.

For many RFSS plants, the habitat conditions in the last 13 years have been suitable for maintaining RFSS plant populations. For some habitat specialist RFSS plants, the Forest has maintained these habitats by avoiding them during forest management and protecting them from direct effects of ground disturbance and habitat change. These habitats are usually stable over

the short term, such as cliffs or forested wetlands, and avoidance by forest management contributes to the maintenance of habitat suitability.

Similarly, for habitat generalist RFSS plants, avoidance during forest management is a simple way to avoid short-term direct effects. However, for some habitat generalist species, succession can disrupt suitable habitat conditions. In contrast to the habitat specialist RFSS plants, forest management that creates earlier seral conditions and improves habitat has been helping maintain habitat conditions for some RFSS plant populations over the last ten years.

Forest management can have indirect effects on RFSS plant habitat conditions in two common ways:

1. By contributing to the spread of non-native invasive species (plants or earthworms).
2. By creating favorable habitat for white-tailed deer that browse young cedar and have big impacts on cedar regeneration, (cedar is an important RFSS plant habitat).

These long-term and slow-acting indirect effects of forest management on RFSS plant habitat can sometimes have, at least for NNIS, irreversible effects.

Implementation monitoring shows that we have implemented 13 out of the 20 projects for RFSS plant habitat improvement that are the objective of O-WL-30. We are behind in progress towards this objective. In part, this is due to lack of opportunities since many of the RFSS plants on the Superior National Forest are habitat specialists. It is also partly due to the challenges of managing deer browsing effects. Reducing deer browse on Canada yew would have positive effects on Canada yew growth and reproduction. Shifting towards harvesting larger patches could create less forest edge and less favorable habitat for deer in the long term, but social pressures for high deer numbers make reducing deer effects a challenging problem.

Recommendations

Presence/absence monitoring of known RFSS plant locations is a very important aspect of fine-filter monitoring of RFSS plants since it helps confirm the continued presence of species in the planning area. Continuing this monitoring is important, especially for detecting any future declines in RFSS plant occurrences.

Forest management may or may not be able to influence climate change-related impacts to RFSS plants. This is especially true for arctic-alpine disjunct plants, which are plant relicts of the last Ice Age but which have persisted in cool microclimates in northeastern Minnesota. Several are RFSS plants, and their ability to persist in the face of climate change is uncertain. A future monitoring need is to detect changes in their populations. Lastly, there is a need to develop an approach to monitor the potential impacts of invasive plants and earthworms on RFSS plants.

References

USDA Forest Service. 2016a. RFSS Plant Coarse Filter Analysis – 2016. 2 p. Administrative report in project record. On file with Forest Supervisor, Superior National Forest, 8901 Grand Ave. Pl., Duluth, MN 55808.

USDA Forest Service. 2016b. Superior National Forest RFSS plant habitat improvement projects. 1 p. Administrative report in project record. On file with Forest Supervisor, Superior National Forest, 8901 Grand Ave. Pl., Duluth, MN 55808.

USDA Forest Service. 2017. Superior National Forest RFSS Plants – 2017. 5 p. Administrative report in project record. On file with Forest Supervisor, Superior National Forest, 8901 Grand Ave. Pl., Duluth, MN 55808.

5.3 Climate Change

As stated in the 2012 Planning Rule directives (36 CFR 219.12(a)(5)), each national forest must incorporate climate change considerations into their monitoring program to monitor "measureable changes on the plan area related to climate change and other stressors that may be affecting the plan area."

In October of 2015, researchers and subject matter experts from six national forests (Superior, Chippewa, Chequamegon-Nicolet, Hiawatha, Ottawa, Huron-Manistee) and four institutions (Northern Institute of Applied Climate Science, U.S. Forest Service Northern Research Station, U.S.A. National Phenology Network, and the University of Minnesota) worked collaboratively to identify key climate change impacts to the Great Lakes area ecosystems. In addition, they identified existing research and monitoring efforts to track those impacts on the Superior National Forest. The topics and questions identified below are a result of this collaboration. The Forest will use them to track how drought and changing winter severity (two different aspects of climate change), are affecting resources within the Superior National Forest Plan area.

Winter Severity

Climate science shows that within the past century, the mean annual temperature in northern Minnesota has increased 2.2°F (1.2 °C) with the largest increase occurring during winter months (3.7 °F, 2.1 °C). What's more, mean minimum temperatures have increased at a faster rate than mean high temperatures. This means that winters on the Superior NF are getting warmer or, more specifically, less cold. This trend is projected to continue with the winter months experiencing the most dramatic warming by the end of this century (Handler et al., 2014).

Because many of the management and recreation opportunities on the Superior NF depend on a winter season, the Forest choses to monitor the changing severity of winter, compared to a number of different management indicators to see how this indicator of climate change affected activities in the Plan area over time.

5.3.1 Winter Severity Monitoring Questions:

How are timing and duration of winter weather conditions changing across the Plan area on an annual basis? How is this affecting the Plan area?

The Midwest Regional Climate Center developed an index for tracking winter severity known as the Accumulated Winter Season Severity Index (AWSSI). This tool provides an objective measure of annual and historic winter conditions using weather station data based on the following variables: maximum/minimum temperature, snowfall, and snow depth (Boustead et al. 2015). As a way to measure changing winter severity across the Plan area, the Superior National Forest adopted this metric and compared it with the following management indicators:

- Number of timber operability days lost: Often times the ability to harvest timber on the Superior NF depends on frozen ground. Because of the large amount of saturated and fragile soil on the Forest, harvesting equipment needs frozen ground to drive on it. Winter harvesting areas are inaccessible when the ground is not frozen. We anticipate that milder winters will result in fewer days of frozen ground, increasing the number of timber operability days lost.

- Number of self-issued Boundary Waters Canoe Area Wilderness (BWCAW) permits: Between the months of October-April, overnight and day-users in the BWCAW enter the wilderness through self-issued permits. Because many recreation activities during that time depend on frozen lakes and abundant snowfall (ice skating, cross-country skiing, snowshoeing, etc.), it is anticipated that milder winters will result in fewer self-issued permits during this timeframe within the BWCAW.

Results

Scientists from the Midwest Regional Climate Change center used historic weather station data to calculate an average AWSSI score for the Superior National Forest for the years 1951-2014. Figure 5.3-1 shows the average AWSSI score for the Superior NF, the extreme score, the mildest score, and the scores for the three most recent winters.

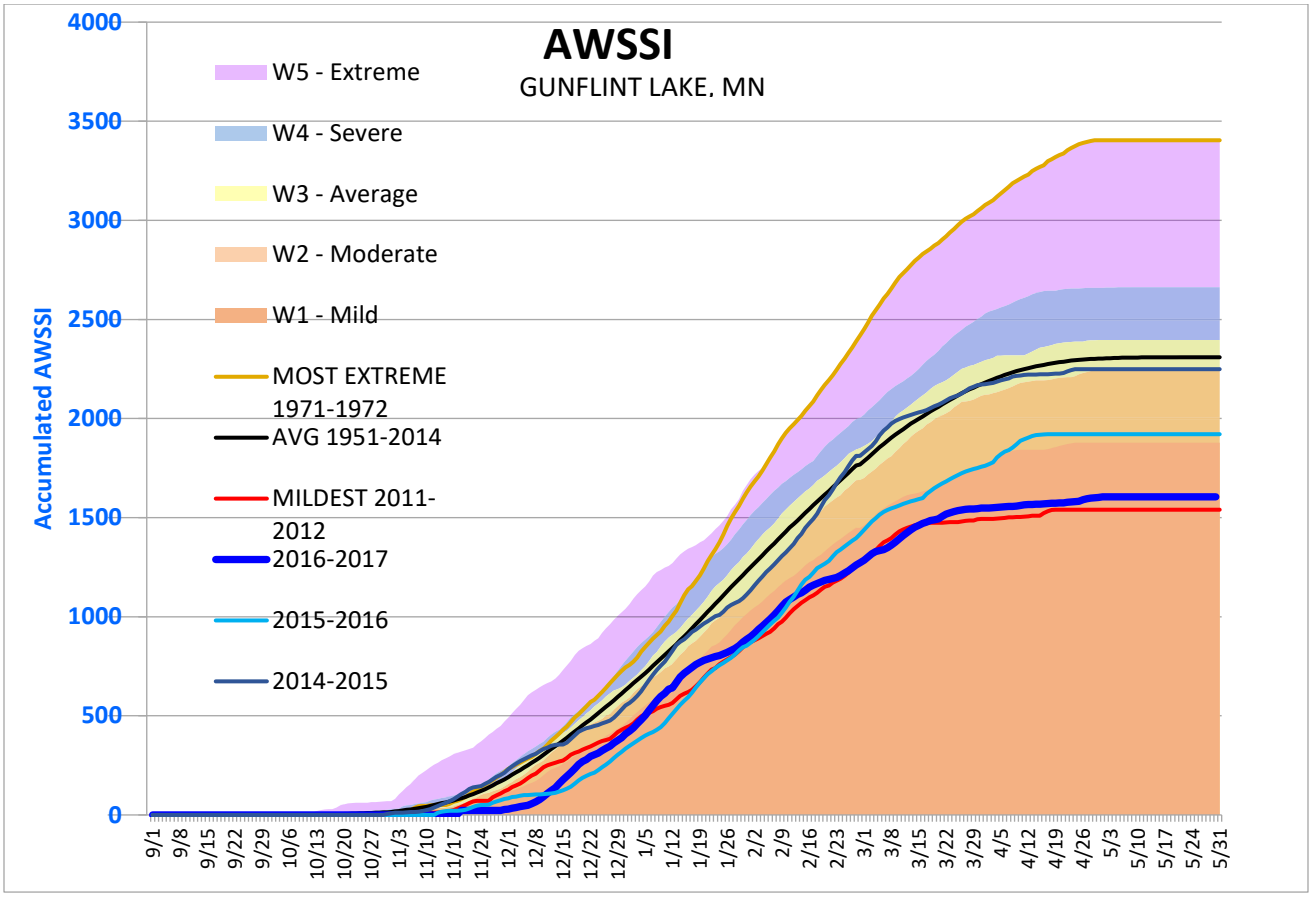


Figure 5.3-1. Average AWSSI scores for the Superior NF, 2014-2017

Figure 5.3-2 shows a comparison of the number of timber operability days lost to the AWSSI score for the 2015-2016 and 2016-2017 winter seasons.

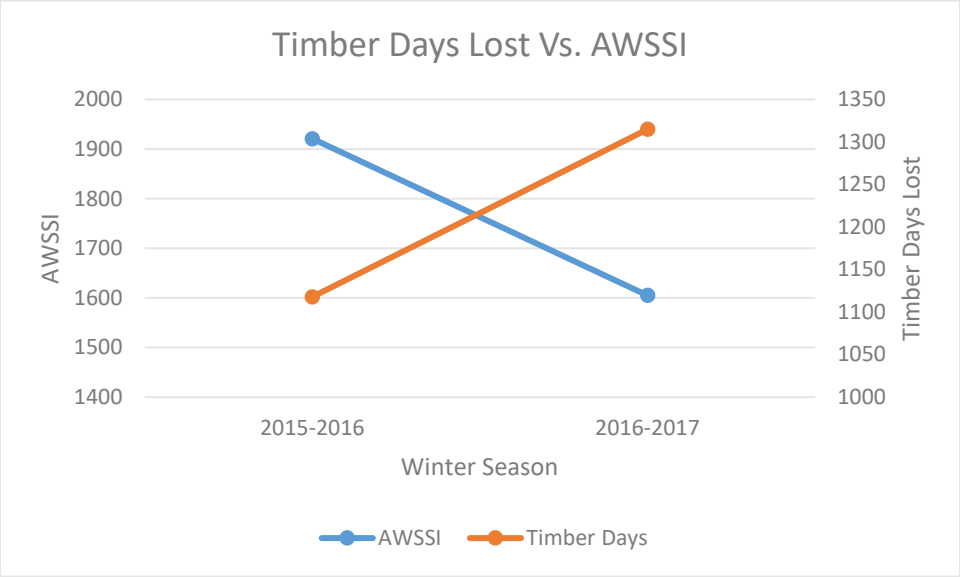


Figure 5.3-2. Timber days lost vs. AWSSI

Figure 5.3-3 shows a comparison of the number of self-issued BWCAW permits from October-April to the AWSSI score for the 2014-2015 and 2015-2016 winter seasons. Because of the way these data are collected, BWCAW permit numbers for the 2016-2017 winter season were not available during the time compiling this report.

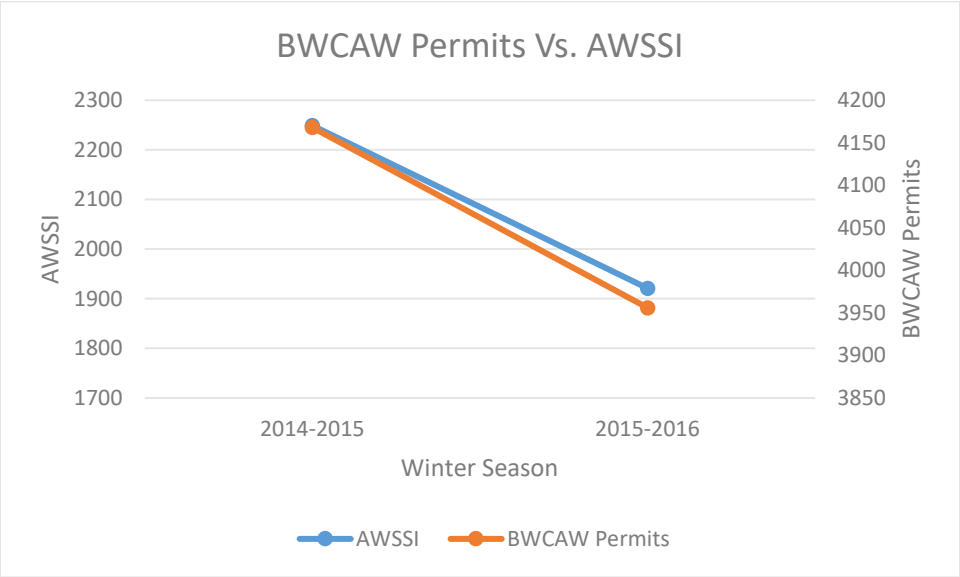


Figure 5.3-3. BWCAW permits vs. AWSSI

Implications

AWSSI Score: The long-term average AWSSI score for the Superior NF is 2309. Figure 5.3-3 displays that the past three winters have become increasingly warmer with the 2014-2015 season

just below average (AWSSI score of 2249), the 2015-2016 season beginning very mild but becoming moderate later in the season (AWSSI score of 1921), and the 2016-2017 season being very mild, nearly matching the mildest winter on the historical record (AWSSI score of 1605). These trends match the observations and predictions noted above, that winters are projecting a warming trend in northern Minnesota.

Timber Operability Days Lost: As predicted, the previous figure shows that milder winters resulted in more timber operability days lost. As the previous two winter seasons went from moderate to mild, the number of timber operability days lost increased from 1,118 to 1,315. While there are still too few data points to determine if this trend will carry forward, these initial findings should give timber managers and timber industry partner's cause for concern as the potential to conduct winter harvest treatments on the Superior NF could be deteriorating.

BWCAW Self-Issued Permits: Also as predicted, the final figure above shows that as the AWSSI score went down over two seasons (i.e. the winters got milder), the number of self-issued BWCAW permits decreased from 4168 to 3,956. Again, there are still too few data points to determine if this trend will carry forward, but these initial results imply that winter recreation opportunities could decrease on the Superior NF if winters continue to warm as predicted.

Recommendations

The Forest has just begun monitoring these two indicators against winter severity, so it is too soon to determine how strongly they correlate to the annual AWSSI score. Initial monitoring results support predictions that timber operability days lost will increase and self-issued BWCAW permits will decrease as winters become milder on the Superior. The Superior NF should continue to monitor these indicators and begin to discuss options for how to accommodate management actions, should these trends continue.

Drought

Climate science shows that, in the Midwest in particular, conditions have been getting wetter since 1950. The Palmer Drought Severity Index finds no detectable trend for increased drought. Since the year 2000, however, the U.S. Drought Monitor has reported six periods where more than 80 percent of Minnesota rated moderately dry or worse. What's more, there has been a clear trend toward extreme precipitation events with a larger proportion of total annual rainfall coming from fewer, more intense events. If rainfall continues to become more episodic, areas in northern Minnesota could become more vulnerable to drought stress (Handler et al., 2014).

While the current lack of a detectable increase in drought conditions over the Plan area is promising, increased drought on the Forest would adversely impact many management opportunities including the survival of tree seedlings due to drought stress and the exacerbation of insect pests and forest disease. For this reason, the Forest chose to monitor yearly drought impacts in comparison to two different management indicators to see if this indicator of climate change is affecting activities in the Plan area over time.

5.3.2 Drought Monitoring Question:

How are drought duration, severity, geographic extent, and timing changing across the Plan area on an annual basis? How is this affecting the Plan area?

The U.S. Drought Monitor (USDM) map is the most prominent composite drought index used within the United States and has been released on a weekly basis since 1999 (Hayes et al., 2012; Svoboda et al., 2002). The map and its associated data are based on measurements of climatic, hydrologic and soil conditions, as well as reported impacts and observations from more than 350 contributors around the country. North Dakota State Climatologist, Adnan Akyuz, worked with the USDM team to develop a method for converting drought levels from the USDM map to a single value for a specific area. This value, known as the Drought Severity and Coverage Index or DSCI, can calculate a score for any given period. For these analyses, the Superior NF calculated the yearly DSCI score for both the west and east zones of the Forest and compared it with the following management indicators:

- Percent seedling survival: After planting tree seedlings on the Forest, staff revisit and monitor the sub-samples for survival one and three years. Staff used third year sample data to calculate the percent of seedlings that survived since planting and compared it to the DSCI number calculated for the year the seedling planting occurred. The Forest anticipates that if planting seedlings in a year with more drought stress (i.e. higher DSCI value); then, survival rates in the third year surveys will be lower.
- Acres affected by forest pests and disease: Each year the Forest performs an aerial survey that detects acres of forest affected by pests and disease such as aspen decline or infestations of spruce budworm, forest tent caterpillar, and eastern larch beetle. The Forest used aerial survey data to calculate the total acreage affected by these factors and compared it to the DSCI value calculated for that same year. Specialists anticipate that in years with more drought stress (i.e. higher DSCI value) pests and disease will affect more acres of the Superior NF.

Results

The Forest compared the percent of seedlings that survived in third-year sampling reports from 2015 and 2016 to the DSCI value for the year the seedlings were planted (2012 and 2013, respectively). Due to its proximity to Lake Superior, drought conditions on the east zone (EZ) of the Superior NF differ from those on the west zone (WZ). Therefore, these zones received separate analyses. The following figures display the results.

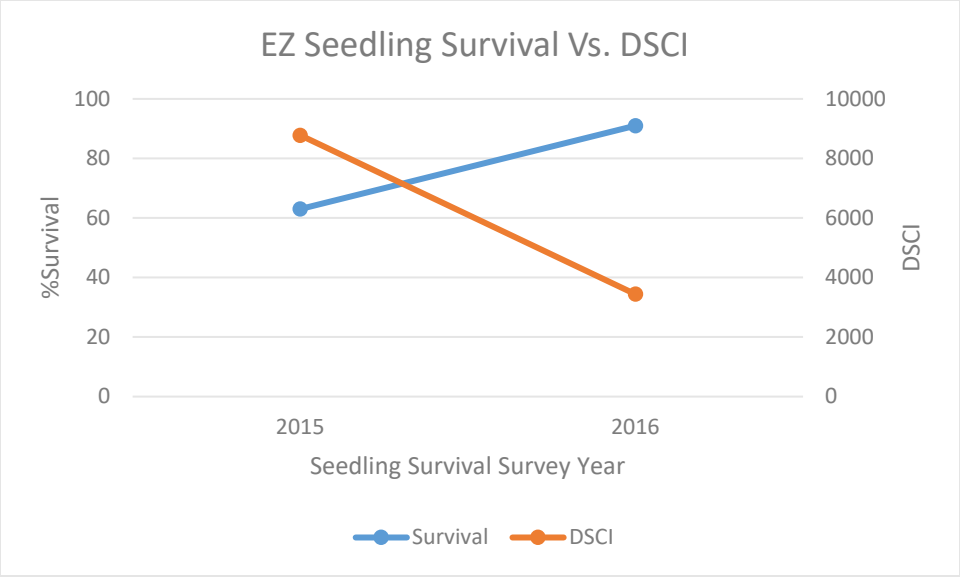


Figure 5.3-4. East zone seedling survival vs. drought severity and coverage index

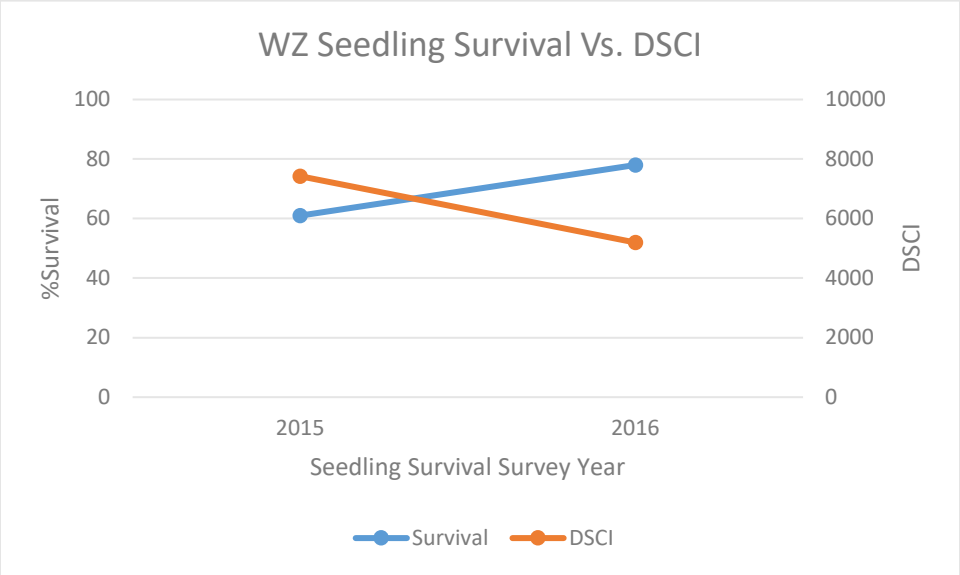


Figure 5.3-5. West zone seedling survival vs. drought severity and coverage index

We compared the number of acres on the Forest affected by insect outbreaks and disease to the DSCI value for the years 2015 and 2016. Due to its proximity to Lake Superior, drought conditions on the EZ of the Superior NF differ from those on the WZ. Therefore, the Superior NF analyzed each zone separately. The following figures display the results.

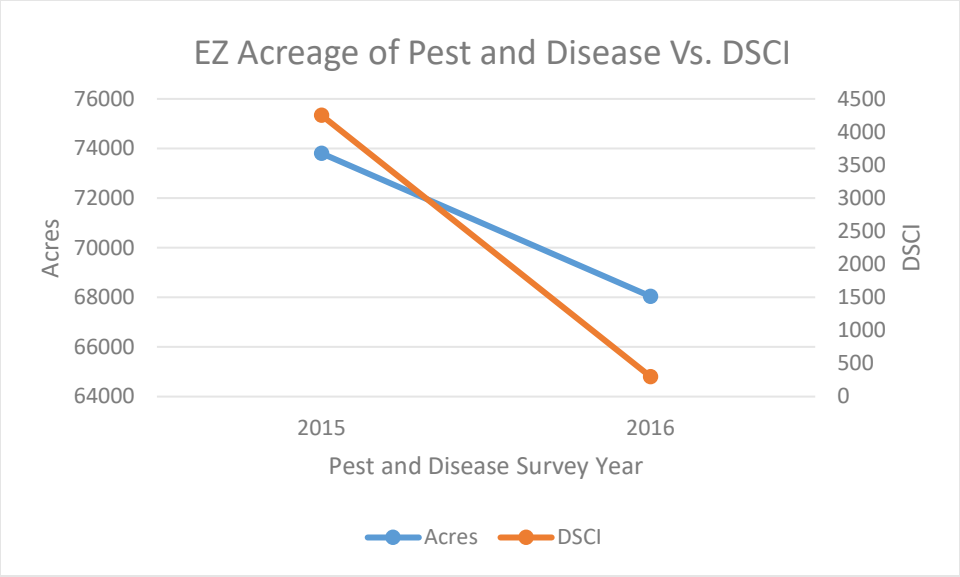


Figure 5.3-6. East zone acreage of pest and disease vs. drought severity and coverage index

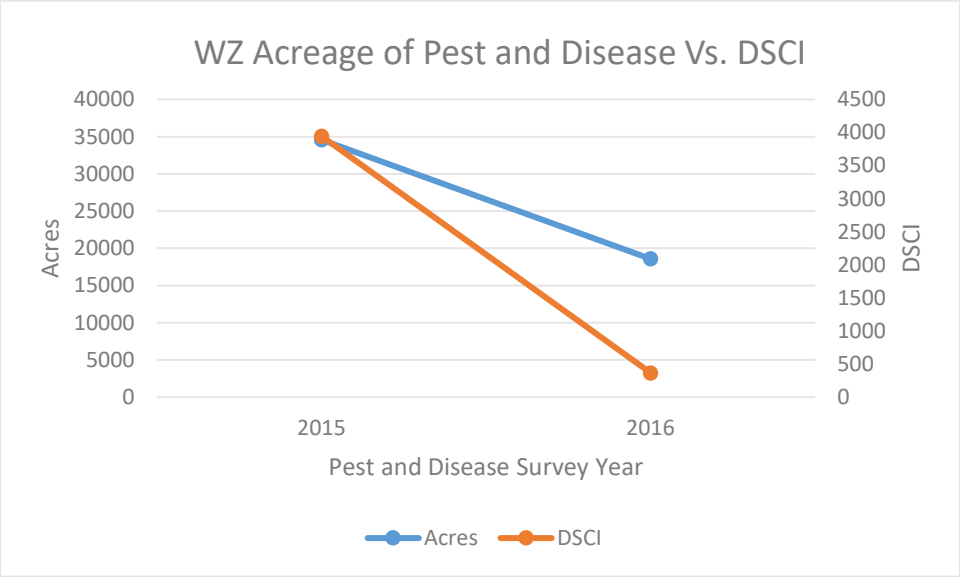


Figure 5.3-7. West zone acreage of pest and disease vs. drought severity and coverage index

Implications

Seedling Survival: As predicted, the above figures show that the more intense the drought, or higher the DSCI score for the year seedlings were planted, the lower the percentage of seedlings that survived three years later. The DSCI scores and seedling survival rates were different between the east and west zones, namely, the magnitude of change for each variable was greater on the EZ. However, the trends were the same on each zone: On years with lower DSCI scores, subsequent survival rates were higher. When looking at these data, the Forest must acknowledge that factors other than drought contribute to seedling survival such as quality of planting stock, planting technique, and deer browse. Further, the Forest has few data points to determine if the detected trend will continue. These initial findings, however, should encourage silviculturists on the Superior NF to pay attention to drought conditions when investing in reforestation efforts.

Forest Pests and Disease: As predicted, the above figures show that in years with more intense drought, insect pest and disease outbreaks affected more acres of the Superior NF. The DSCI scores and total number of affected acres were different between the east and west zones, however, the trends were the same on each zone: On years with lower DSCI scores, infestations and outbreaks affected fewer acres. One interesting observation not depicted in the figures relates to aspen decline. Research shows that drought stress can be a contributing factor in aspen decline (Michaelian et al. 2010). In the year 2016, a very mild drought year, there were no acres of aspen decline reported on either zone. In 2015, a much more severe drought year, aspen decline occurred on nearly 12,000 acres across the two zones. There are too few data points to determine if the detected trend will continue. These initial findings, however, should encourage silviculturists on the Superior NF to pay attention to drought conditions when assessing the risk of forest pests and disease.

Recommendations

The Superior NF has just begun monitoring these two indicators against drought severity, so it is too soon to determine the strength of correlation to the annual DSCI score. In addition, while values differed for each indicator between the east and west zones, the trends detected were the same. In addition, it is too soon to tell whether dividing the analysis by zone will bring distinct information or whether the Superior NF as a whole should be analyzed. Initial monitoring results support predictions that seedling survival will decrease and forest pest and disease acreage will increase as droughts become more severe on the Superior. The Superior NF should continue to monitor these indicators and begin to discuss options for how to accommodate management actions, should these trends continue.

References

Boustead, Barbara E. Mayes; Hilberg, Steven D., Shulski, Martha D., Hubbard, Kenneth G. 2015. The Accumulated Winter Season Severity Index (AWSSI). Journal of Applied Meteorology and Climatology.

Handler, Stephen; Duveneck, Matthew J.; Iverson, Louis; Peters, Emily; Scheller, Robert M.; Wythers, Kirk R.; Brandt, Leslie; Butler, Patricia; Janowiak, Maria; Shannon, P. Danielle; Swanston, Chris; Barrett, Kelly; Kolka, Randy; McQuiston, Casey; Palik, Brian; Reich, Peter B.; Turner, Clarence; White, Mark; Adams, Cheryl; D'Amato, Anthony; Hagell, Suzanne; Johnson, Patricia; Johnson, Rosemary; Larson, Mike; Matthews, Stephen; Montgomery, Rebecca; Olson, Steve; Peters, Matthew; Prasad, Anantha; Rajala, Jack; Daley, Jad; Davenport, Mae; Emery, Marla R.; Fehringer, David; Hoving, Christopher L.; Johnson, Gary; Johnson, Lucinda; Neitzel, David; Rissman, Adena; Rittenhouse, Chadwick; Ziel, Robert. 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p.

Hayes, Michael J.; Svoboda, Mark D.; Wardlow, Brian D.; Anderson, Martha C.; and Kogan, Felix. 2012. Drought Monitoring: Historical and Current Perspectives. Drought Mitigation Center Faculty Publications. 94. http://digitalcommons.unl.edu/droughtfacpub/94

Michaelian, Michael; Hogg, Edward H.; Hall, Ronald J.; and Arsenault, Eric. 2010. Massive mortality of aspen following severe drought along the southern edge of the Canadian boreal forest. Global Change Biology.

Svoboda, M. D., D. LeComte, M. J. Hayes, R. Heim, K. Gleason, J. Angel, B. Rippey, R. Tinker, M. A. Palecki, D. Stooksbury, D. Miskus, and S. Stevens. 2002. The Drought Monitor. An Integrated Approach to Water Supply Assessment. Bulletin of the American Meteorological Society 83 (8):1181-1190.

5.4 Fuels Reduction and Wildland Fires

Fuels reduction entails tracking the number of treated acres for hazardous fuels reduction through fire, mechanical treatment, and timber harvest activities during 2013 – 2017. Moreover, tracking helps to disclose the effectiveness of these treatments in meeting resource objectives. The wildland fire sub-section tracks the number of unwanted wildfires by causal category and acreage, along with the number of wildfires the Forest managed for resource benefits during 2013 - 2017.

5.4.1 Fuels Reduction Monitoring Question

How, where, and to what extent will prescribed fire and/or mechanical treatment be used to maintain desired fuel levels, mimic natural processes, maintain/improve vegetation conditions, or restore natural processes and functions to ecosystems?

Monitoring Indicator(s)

Considering acres and types of fuels reduction treatment and their effectiveness in achieving resource objectives is the monitoring indicator for the monitoring question. Information used in this consideration includes:

- 1-1000-hour fuel loadings.
- Duff and litter depths.
- Overstory pine mortality.

Managers can use the information from these indicators to help determine the most appropriate treatment methods and locations to reduce hazardous fuel loadings and improve the natural process of the ecosystems within the forest.

Monitoring Frequency

Collection of monitoring information for the indicators occurs every one to five years.

Forest staff reviewed the fuels treatment accomplishments in the FACTS database for five years. The information was broken down into prescribed fire (understory/broadcast and piles) and mechanical treatments (harvest and other).

Background & Driver(s)

The Forest conducted monitoring to address the following objectives from the Forest Plan:

- O-ID-2: Establish, maintain, or improve the condition of vegetation using prescribed fire, mechanical treatments, and other tools.
- O-ID-3: Treat areas of highest fire risk to minimize effects of unwanted wildland fire.
- O-ID-4: Reduce fuels and control vegetation in the under-story of stands that had naturally occurring low intensity surface fires.

Monitoring Indicator:
Results and Discussion

The Forest completed 43,585.6 acres of hazardous fuels reduction during the timeframe of 2013 - 2017. Of these acres treated, 4,366 acres used prescribed fire by understory or broadcast burning and 5,428 acres of pile burning. Prescribed burning acres accomplished during this timeframe

ranged from a low of 463 acres in 2017 to a high of 1,501 acres in 2015. Environmental parameters, such as too wet or too dry, generally determine the accomplishable amount of prescribed burning. There were no prescribed burns conducted within the Boundary Waters Canoe Area Wilderness (BWCAW) during the timeframe. Additionally, the Forest managed two lightning fires located within the BWCAW for resource improvement (wildland fire section).

The remaining 33,791.6 acres were treated by mechanical means such as shearing, pruning, thinning, and harvest. Timber harvest accounted for 15,691 acres of fuels reduction, and utilized other mechanical methods treated the remaining 18,100 acres.

Generally, sampling of the 1-1000-hour fuel loadings for the underburn units showed a decrease of 50-55 percent in the tons/acre remaining within the burn unit. These units had reduced duff depths of 95 percent, and decreased litter depths of 40-80 percent depending on the burn. Mortality of the overstory pine within the units was limited to less than five percent.

5.4.2 Wildland Fires Monitoring Question

What level of wildland fire on the landscape is appropriate and desirable, and to what extent is unwanted wildland fire on the landscape suppressed?

This question tracks trends in the number of wildland fires and the causal agents that are occurring on the forest. With these trends, fire managers can use the information to determine future needs within in the fire program such as changes to prevention needs, changes areas that can allow fires to burn for resource improvement, changes in needs for hazardous fuels treatments, etc.

Monitoring Indicator(s)

Tracking of wildland fires that have occurred on the forest over the last 20 years included reviewing the FIRESTAT database, which is the repository for the individual fire reports. The individual reports went into a spreadsheet that broke down both the causal agent of the fire and the fire size. The individual fire reports also identify if the fire was managed for resource improvement.

Background & Driver(s)

The Forest conducted monitoring to address Forest Plan the desired condition:

- D-ID-6: The presence of wildland fire on the landscape is appropriate and desirable, but unwanted wildland fire is actively suppressed where necessary to protect life, investments, and natural resources.

Monitoring Indicator:
Results and Discussion

Based on fire reports completed for each wildland fire that occurred within the protection area of the Superior National Forest, from 2013-2017, 113 wildfires burnt a total of 2,302 acres (table 5.4-1).

Table 5.4-4. Fires from 2013-2017 on the Superior National Forest

Year	Number of Fires	Acres Burnt
2013	29	221
2014	19	30
2015	28	131
2016	21	1,917
2017	16	3
Total	113	2,302

These figures were short of the 20-year average of 51 fires and 10,685 acres for the forest. The 20-year average for acreage burnt is a result of three years (2006, 2007, and 2011) with large fires that inflated the average. During 2013-2017, the smallest fire was one-tenth acres, the largest was 973 acres, and the average wildfire acreage burnt was 20.4 acres. There were ten fires that burnt over five acres during the timeframe.

The Forest Plan allows for management of lightning-caused fires within certain portions of the BWCAW for resource improvement. Of the nine fires that occurred within the BWCAW during 2013-2017, the Forest managed two fires for resource improvement. The combined fires totaled 202 acres with the largest being the Knife Lake fire at 188 acres.

Table 5.4-2 displays 2013 - 2017 fires, acres burned, and time of year fires occurred for fires five acres or larger. Table 5.4-3 shows wildfire acres burnt during 2013-2017 and also the 20-year average for each statistical cause. Table 5.4-3 shows the number of wildfires by statistical cause during the past five years and also the 20-year average.

Table 5.4-5. Wildfires five acres or larger, 2013-2017

Fire	Acres Burned	Time of Year
Carpenter Road	14	May 2013
Reed Road	13	May 2013
Knife Lake	188	August 2013
Sullivan Creek	10	May 2014
Disappointment	13	June 2014
Breda Maki	11	March 2015
Sand Lake Complex	85	May 2015
Silver Island	30	August 2015
Skibo	973	May 2016
Foss Lake	936	May 2016

Table 5.4-6. Wildfire acres for past five years and fire cause

Cause	2013	2014	2015	2016	2017	20-Year Average
Lightning	189.0	13.1	31.1	0.0	1.0	6,742.1
Equipment	0.1	0.0	0.1	0.5	0.1	4.6
Smoking	0.5	0.0	0.0	0.0	0.0	0.2
Campfire	14.5	2.8	1.1	1.5	0.6	3,782.3
Debris Burning	0.7	0.2	11.8	4.0	0.0	7.4
Railroad	0.0	10.0	0.0	973	0.0	58.7
Arson	0.0	0.4	0.0	0.1	0.0	5.6
Children	0.0	0.0	0.0	0.0	0.0	2.8
Misc.	16.3	3.1	87.9	938.1	1.2	80.9
TOTALS	221.0	29.6	131.2	1,917.2	2.9	10,684.5

Recommendations

Monitoring for prescribed fire effectiveness implies that fuels treatments on the SNF are addressing fuel objectives in the Forest Plan.

The question of how much wildland fire is appropriate and desirable, and to what extent should it be suppressed can be seen with the monitoring results. The results show that the major causal agents of wildland fire on the forest are lightning and campfires over the last 20 years. Of all the causal agents, only lightning-caused fires can be considered desirable, and then only if they are located within the area of the BWCAW that allows natural ignitions to be managed for resource improvement. The Forest considers all human-caused fires unwanted and thus have an immediate suppression strategy.

The results show that the trend for escaped campfires is a large contributor to wildland fire and identifies a possible need for increased prevention and education with forest visitors to reduce the instances of these types of wildland fire.

5.5 Minerals and Geology

The Superior National Forest (SNF) contains vast economic deposits of hardrock mineral resources. Located within the Mid-Continent Rift system, the Duluth Complex underlies a substantial portion of the SNF. Exploration for copper and nickel, generally along the basal contact of the Duluth Complex, has been underway since the late 1940s and continues today with an increasing interest in exploration for platinum group metals (PGEs). In the last decade, as metal prices have become more favorable for development and production, exploration for hardrock minerals in this region has increased substantially. To date, Polymet is the only plan for development of hardrock minerals on SNF lands. However, a decision regarding the proposed use conflicts on the exchanged lands occurred due to the acquiring purposes of the lands. Therefore, the SNF no longer manages the surface lands affected by the proposed mine. Elsewhere on the Forest, hardrock minerals activities have been limited to exploration and baseline environmental studies.

The latest advance and retreat of the Wisconsin-age Rainy and Superior lobes of the Laurentide ice sheet exposed bedrock by glacial abrasion and scour, and deposited vast amounts of ice marginal, and ice-contact sediments. As a result, the SNF has a very active mineral material program that includes two dimension stone quarries operating since the early 1990s. These quarries utilize a large long-term preference right negotiated sale contract for sand and gravel, along with approximately 400 gravel pits. As a result, the SNF remains one of the largest source of aggregate materials for development and road construction projects in northeastern Minnesota.

The Federal Government expresses its policy for minerals resource management in the Mining and Minerals Policy Act of 1970, " to foster and encourage private enterprise in:

1. The development of economically sound and stable domestic mining, minerals, metal and mineral reclamation industries.
2. The orderly and economic development of domestic mineral resources, reserves, and reclamation of metals and minerals to help assure satisfaction of industrial, security and environmental needs."

Additionally, the Forest Service expresses its policy for minerals resource management in the Forest Service Manual: The mission of the Forest Service in minerals management is to encourage, facilitate, and administer the orderly exploration, development, and production of mineral and energy resources on National Forest System lands to help meet the present and future needs of the Nation.

This section of the report addresses two subsections, including exploration, and the development and production of mineral resources.

Exploration

Exploration is how an operator determines the presence, extent, value, and preliminary processes of extraction and refinement of a mineral ore. Additionally, exploration can include an investigation of affected natural resources by the exploration, development, and production of mineral resources. Exploration can take the form of core drilling, trenching, testing holes, monitoring well construction, geophysical surveying, mapping, and hand sample collecting of potential ores, or soil and vegetation sampling. Most exploration requires access to a particular area; access can vary from water access (landing construction) to motorized vehicle and

equipment access to foot travel. Most exploration for mineral resources on the SNF requires the construction of access roads. Non-destructive exploration (i.e. biological sampling) usually does not require the need to construct access roads.

Over the last twelve years (2006-2017), exploration for hardrock leasable minerals (copper, nickel, and PGEs) and monitoring well construction has been the primary form of exploration activities on the SNF. Exploration has taken place on two federal leases currently under the control of Twin Metals LLC, on federal prospecting permits, and on non-federal mineral estates. Seppi Brothers Concrete Products (Seppi), which holds a preference right negotiated contract, also conducted exploratory work in 2008 by excavating test pits to continue their sand and gravel operations on National Forest System (NFS) lands. Exploration of hardrock minerals largely uses core drilling, which historically required a truck mounted, or skid type, drill rig and associated equipment, the clearing and grubbing of timber for a drill pad and access road, use of a sump pit for cuttings storage, and water for lubricating the drill bit and flushing cuttings from the core hole.

5.5.1 Exploration Monitoring Question:

Are mineral exploration avoidance or mitigation measures effective and following the project design recommendations?

The drivers of this monitoring question are Forest Plan desired conditions D-MN-1 and D-MN-2. The three standards and guidelines that directly relate to these types of activities are mitigations to protect surface resources (S-MN-12 and 13, Forest Plan p. 2-10) and reclamation (G-MN-1, Forest Plan p. 2-10).

The Bureau of Land Management (BLM) approves operations on federal hardrock minerals. The BLM solicits resource stipulations for new permit or leasing actions, or operating conditions for proposed operations on existing leases or permits, from the surface managing agency. Additionally, if a special use permit (SUP) is required for an operator to exercise mineral rights, a suite of stipulations is developed to mitigate effects to resources.

Mineral materials exploration includes mitigation measures and standards from the environmental analysis conducted for the contract/exploration approval decision, or for small sales in active and well-established gravel pits. Additionally, it utilizes mitigations and monitoring standards though pit planning, on a site-specific basis, or on an individual operating plan. Forest Service concurrence of non-federal minerals operations also requires the implementation of mitigation measures and monitoring standards to protect natural resources to the greatest extent possible; however, specific measures are negotiable with the operator. The operating plan lists the standards measuring the monitoring efforts as submitted by the operator, and developed during an interdisciplinary review of the proposal. Yet, regardless of the mitigation or type of authorization, resource specialists reviewing the proposal or conducting the environmental analysis refer to the Forest Plan and best management practices (BMPs) for avoidance, mitigation measure, and monitoring standard development.

The monitoring indicators used in exploration projects include:

1. Inspection of equipment mobilized to the Forest for non-native invasive species (NNIS), calculation of acres of disturbance, and length of temporary access roads.
2. Determination of volume and rate of water withdrawn for stream flow and lake elevations.
3. Measurement of sound pressure levels at established boundaries.

4. Determination of presence/absence of NNIS in disturbed areas.
5. Finding of evidence of rutting and soil compaction, presence/absence of fill in wetlands, documentation of sump failure/success, and chloride concentrations in drilling fluid.
6. Assessment of effectiveness of road decommissioning.
7. Determination of the presence/absence of a temporary or permanent seal on core holes.

In addition to these indicators, monitoring of exploration operations also includes the completion of interim and final reclamation through:

a) Effective use of safety and fire control measures.
b) Adequate avoidance and minimal disturbance to wildlife.
c) Acceptable visual impacts and avoidance of heritage resources.
d) Proper location of occupancy as per standards identified in the relevant project stipulations.

Monitoring of these indicators assures that operations conform to the mitigations bound to the authorization, contract, or concurrence, and adequately protect Forest resources. The accepted operating plan define the standards for measuring these indicators, and/or the environmental analysis conducted for authorization of the proposal. The goal is to facilitate mineral exploration and development on the national forest while incorporating best management practices (BMPs) and mitigation measures into authorizations that protect, sustain, and restore Forest resources. The Forest documents monitoring and mitigation effectiveness by completing a monitoring form and collecting spatial data during each inspection. This information assists the Forest in developing effective future project authorization requirements that meet goals established in the Forest Plan.

Results

The exploration for sand and gravel by Seppi was completed; all mitigations properly implemented. In total, completion of six test holes (pits dug with an excavator) occurred over the course of one day in November of 2008. An SNF representative was on site, a geological report was completed, test holes fully reclaimed, and roads properly decommissioned after exploration was completed.

During 2006-17, monitoring of 81 hardrock minerals projects occurred in the field for approximately 243 days, permitting 38 hardrock minerals exploration operations on federal minerals, and giving concurrence for 43 operations on private minerals estates on NFS lands by the Forest Service. Drilling occurred on only 419 holes despite 623 permitted drill holes.

Table 5-5.1 shows the results of hardrock minerals exploration monitoring for some of the indicators listed above. The bulk of exploration was core drilling; however, construction for a series of hand driven and sonic drilled water monitoring wells occurred between 2015 and 2017. The construction of water monitoring wells uses similar equipment and operations as core drilling; some constructed wells use the same core drilling methods.

	Approved Operations*	Core Holes/Excavations Permitted	Core Holes/ Wells/Excavations Completed	Sump Failure	Acres Disturbance: Drill Pads	Temp Road Length (mi)	NNIS Present	Fill in Wetlands	Effective Road Decom.	Perm./Temp. Seal
Federal Minerals Projects	38	225	195	0	6.6	7.21	Y	0	Y	Y
Non-Federal Projects	43	398	224	0	13.1	17.37	Y	0	Y	Y
Mineral Materials Projects	1	22	6	0	<1	0	N	0	NA	NA

Table 5-5.1. Monitoring Indicator Results

*Includes operating plans and amendments.

Over the last decade, SNF monitoring efforts show that exploration activities were in conformance with approved operating plans and largely, followed mitigation and best management practice requirements and adequately protecting Forest resources. Specific examples include the lack of effects on water body elevations and flow rates in streams from water withdrawals to support core-drilling operations, absence of fill in wetlands, minimal rutting and no evidence of soil compaction at drill sites and access roads, and the apparent effectiveness of sump design to contain and dispose of cuttings without failure (figure 5-5.2). Interim and final reclamation measures were adequate and completed in an acceptable period including the temporary and permanent sealing of core holes in accordance with MN Department of Health regulations (figures 5-5.3, 5-5.4).

Figure 5.5-1. Final reclamation or road decommissioning

Figure 5.5-2. Effective sump

Figure 5.5-3. Permanent seal

Figure 5.5-4. Interim reclamation

Occasionally, monitoring discovered unfollowed mitigations measures; however, mostly the action was unintentional and all resulted in corrective action as soon as possible by the company conducting the exploration operations. Some specific examples include:

- National Forest System and temporary access roads rutting on the 2010 Greenwood Lake South, 2012 prospecting permit 055203 (drill pad ES-01, figure 5.5-6), and the 2006 Duluth Metals Limited projects.
- The 2015 Twin Metals partial sinking of a parked forklift on a frozen wetland (figure 5.5-5).
- Occasional small (less than 5 gal.) cuttings spills near the core hole.
- Encampment Skibo 2013 project digging of a small plastic lined sump in a wetland.
- Duluth Metals Ramasa 2013 project merchantable timber bulldozed over instead of felled.
- Encampment Greenwood Lake South 2010 project contractor bulldozer crossed Petrel Creek without the construction of a proper crossing.
- Lehman Bob's Bay 2008 project unfenced sump.
- Encampment Siphon 2008 project improperly decommissioned access roads.

- Duluth Metals prospecting permits 2013 water withdrawal from an unapproved source.

Figure 5.5-5. Inadequate frost depth

Figure 5.5-6. Rutting

Additionally, the presence of common non-native invasive plants (NNIP) have been an issue on sites where ground disturbance has occurred. Exploration companies are responsible for preventing NNIP establishment and remediating NNIP infestations along with the annual SNF NNIP remediation program. Although occasional mistakes occur and mitigations not followed on a few occasions, the exploration companies that have been, and are currently active on the SNF have been very responsive to correct mistakes by employees and subcontractors.

Chloride Testing

Exploratory drill holes with elevated levels of chloride (greater than 250 mg/L, or ppm) that exist within 500 feet of an existing well terminating in bedrock, require permanent abandonment within one week of completion unless the case of core hole is at an elevation 50 feet below the deepest well within the 500-foot radius. Table 5.5-2 shows the results of chloride concentration testing in recent exploratory drill holes. On only one occasion was chloride levels above 250 mg/L; NE-03 is not located within 500 feet of an existing well that terminates in bedrock, therefore a permanent seal was not required immediately after completion of downhole testing.

Table 5.5-2. Chloride testing results

Lease No.	Pad No.'s	Depth (ft)	Date	Cl (ppm)
53868	NE-03	1118	9/27/2012	50
53868	NE-03	2100	10/1/2012	43
55206	ES-09	429	10/22/2012	50
53868	NE-03	2990	10/24/2012	1567
55206	ES-09	998	10/24/2012	70
53868	NE-03	129	11/6/2012	<30
Ramasa	RAM-02	4417	11/6/2012	100
54037	NE-25	1200	12/18/2012	190
Ramasa	RAM-03	286	1/15/2013	<30
1352	P05	328	1/28/2013	<30
53868	NE-44	676	1/28/2013	<30
1352	P02	Unknown	2/20/2013	<30
1352	P16	Unknown	2/20/2013	<30
Ramasa	RAM-04	Unknown	2/20/2013	160
54037	TJ-02	70	2/12/2014	148
54037	TJ-02	205	2/12/2014	161
54037	TJ-01	40	2/14/2014	136

Acoustical Monitoring

Noise generated from minerals exploration operations has been an issue identified by the public since the mid-2000s. Since then, project designs incorporate mitigation measures to limit the disturbance from noise generated during hardrock minerals exploration activities. The State of MN rules apply to all drilling operations. In addition, the SNF has required that operators reduce sound levels to a maximum of 70 dBA at 20 feet for most drilling operations. During the comment period for the Federal Hardrock Minerals Prospecting Permits EIS (PPEIS), potential noise from exploratory drilling operations was a major issue and resulted in the alternative selected for the issuance of 29 new prospecting permits in 2012. The stipulations regarding noise in the record of decision (ROD) require operators to reduce noise to an L50 level of 30 dBA and an L10 level of 35 dBA at the boundary of the BWCAW.

Drilling companies have been meeting the mitigation measures by utilizing mitigation baffling around engines, adjusting the location of drilling operations, and using vertical exhaust extensions. For example, the 2013 federal prospecting permit MNES-053868 deployed acoustic monitoring equipment at the BWCAW boundary for core drilling operations underway on drill pad NE-44. Additionally, on March 7, 2013, acoustical monitoring equipment was deployed while active drilling operations were located west 0.36 miles due west from the edge of the BWCAW. These data show that noise levels were below 30 dBA for 71.5 percent of the deployment, and that noise levels only exceeded 35 dBA for six percent of the monitoring period. This deployment was conducted in a “worst case” condition; leaves were off and the instrument was almost directly downwind of the drilling (gust direction of 290 degrees). Drilling operations noise did not exceed the thresholds identified in the PPEIS. In total, acoustic monitoring equipment deployment occurred eight times for sample periods of up to 30 days to monitor background sound levels, and noise generated from core drilling and monitoring well construction. The acoustical data analyzed to date indicates that exceedance of noise mitigation thresholds has not occurred.

Figure 5.5-7. Sound attenuation panels at a core-drilling site

In summary, monitoring determined that aside from a few isolated incidents over the last decade, the drilling companies followed the mitigation and best management practice requirements and met desired conditions. Stipulations and mitigation measures developed for exploration projects have adequately protected Forest resources.

Development and Production

Development of a mineral resource involves the initial investment and construction preceding extraction of the resource and can include the stripping of overburden, clearing of timber and general site prep, and the construction of facilities and ancillary infrastructure. Production of a mineral resource is the actual mining of the resource for direct sale, or shipping for further refinement of the mineral resource.

In the last decade, mineral resource development has been limited to timber removal, the stripping of overburden for mineral material production, and pit management planning. Production of mineral resources on the SNF has been limited to the Seppi sand and gravel contract, gravel sales/contracts from SNF gravel pits, and the Mesabi Black (MBQ) and Lake Superior Green (LSG) dimension stone quarries operated by Coldspring. It is common practice to combine the development and production into a single proposal for mineral material operations on the SNF; the environmental analysis conducted for the decision and mitigation measures considers both development and production as a single entity.

5.5.2 Development and Production Monitoring Question:

Are mineral development and production avoidance or mitigation measures effective and following project design features?

The drivers of this monitoring question are desired condition D-MN-1 and D-MN-2. The three standards and guidelines that directly relate to these types of activities are mitigations to protect surface resources (S-MN-12 and 13, Forest Plan p. 2-10) and reclamation (G-MN-1, Forest Plan p. 2-10).

Similar to exploration, mineral materials development and production mitigation measures are derived from the either the environmental analysis conducted for the contract/production approval decision, or for small sales in active and well-established gravel pits mitigations, are developed though pit planning on a site specific basis or individual operating plan. Resource specialists reviewing the proposal, or conducting the environmental analysis, refer to the Forest Plan and best management practices (BMPs) for avoidance and mitigation measure development.

The monitoring indicators used in development and production operations are the same indicators used for exploration projects. In addition to these indicators, monitoring of development and production operations includes:

- Conformance with operating plan.
- Completion of concurrent reclamation.
- Minimization of disturbance.
- Undermining of timber.
- Stockpiling of topsoil and slash for reclamation.
- Using effective safety and fire control measures.
- Adequately avoiding and minimally disturbing wildlife.
- Acceptable visual impacts.
- Avoidance of heritage resources.
- Controlling erosion and pollution.
- Reporting production.
- Proper locations of occupancy identified in the relevant project stipulations.

Indicator monitoring assures that operations conform to the mitigations bound to the authorization or contract, while protecting Forest resources. The goal is to facilitate mineral exploration and development on the national forest while incorporating best management practices (BMPs) and mitigation measures into authorizations that protect, sustain, and restore Forest resources. The Forest documents monitoring and mitigation effectiveness by completing a monitoring form and collecting spatial data during each inspection. This information assists the Forest in tracking production/development, and developing effective future authorization requirements for projects that meet goals established in the Forest Plan.

Results

Gravel Pit Planning and General Gravel Pit Monitoring

In total, 20 pit management and development plans were followed for sand and gravel development and production operations from SNF gravel pits. Each gravel pit had avoidance and mitigation measures tailored to site-specific resource issues. At times, modification occurred to include a specific operating plan/proposal for larger contracts. Table 5-5.3 shows the number of contracts/sales, annual quantity, and revenue generated from sand and gravel sales in the last decade.

Table 5.5-3. Sand and gravel production and contracts

	Contracts			Free Use Permits			In-Service Use	
YEAR	#	Short Tons	$	#	Short Tons	$	Short Tons	$
2006	45	186509	$123,788.00	21	301	$204.00	7588	$5,149.00
2007	128	164688	$89,444.00	24	171	$114.00	183464	$122,740.00
2008	155	172919	$133,765.00	14	235	$165.00	22645	$15,150.00
2009	92	203384	$143,244.00	26	184	$124.00	3391	$2,299.00
2010	139	166191	$116,446.00	21	10777	$7,218.00	54734	$36,801.00
2011	141	110175	$78,787.00	13	92	$62.00	0	$0.00
2012	140	186674	$136,352.00	16	436039	$291,717.00	4835	$3,240.00
2013	88	157225	$110,866.00	5	35	$24.00	9147	$7,605.00
2014	124	232739	$181,109.00	9	476	$399.00	25816	$17,316.00
2015	63	303594	$211,472.00	42	23850	$15,986.00	0	$0.00
2016	96	224706	$175,751.00	43	302	$324.00	44251	$37,352.00
2017	80	182228	$151,857.00	55	3271	$2,843.00	4334	$3,331.00
Total	1291	2291032	$1,652,881.00	289	475733	$319,180.00	360205	$250,983.00
12yr Avg	108	190919	$137,740.08	24	39644	$26,598.33	30017	$20,915.25

Approximately 198 days were spent monitoring sand and gravel pits operations. On a few occasions, standing timber was undermined and allowed to fall into the pit. However, this occurred mostly in small pits with small sales that do not require continuous monitoring during material extraction. Non-native invasive species (NNIS) continues to be an issue; however, the SNF has an active abatement program to control NNIS to the greatest extent possible. In one instance, the Shamrock pit from the Highway 1 project contained waste material into the adjacent standing timber. Forest staff notified the operator who subsequently removed the material from the area. In addition, in 2015, Forest staff discovered that mining in the North Arm pit had taken place under the water table without prior approval. It was determined the mining had taken place during a dry time of the year and was not done intentionally; subsequent County operations corrected the issue. In general, monitoring efforts determined that operations were in conformance with approved operating plans, following mitigation and best management practice requirements, and adequately protecting resources. Specific examples include adequate production reporting for large sales, the lack of erosion issues and fill in wetlands at existing pits, and sufficient reclamation during and after pit operations (figure 5.5-8).

Figure 5.5-8. Highway 1 Reconstruction Project: Denley Pit Reclamation

Seppi – Jammer Lake Gravel Pit

Seppi has been operation under a preference-right negotiated contract in the Jammer Lake gravel pit since the mid-1970s. In the last decade, the Forest monitored Seppi operations for 67 days and observed no monitoring issues. Concurrent reclamation and planting has been completed as detailed in the stipulation/mitigations attached to the contract (figure 5.5-9), production reporting has been accurate, advanced payments timely, and topsoil stripped and stockpiled for reclamation purposes.

Table 5.5-4. Seppi annual production and royalties

YEAR	NET CUBIC YARDS	VALUE
2006	80,766	$ 76,727.70
2007	77,382	$ 73,512.90
2008	80,238	$ 76,226.10
2009	72,353	$ 68,735.35
2010	80,484	$ 76,459.80
2011	79,857	$ 75,864.15
2012	81,483	$ 77,408.85
2013	81,641	$ 77,558.95
2014	72,353	$ 68,735.35
2015	80,414	$ 76,393.30
2016	85,871	$ 81,577.45
2017	109,887	$ 104,392.65
TOTAL	982,729	$ 933,592.55

Figure 5.5-9. Seppi Concrete Bros. operations final reclamation

Coldspring Dimension Stone Quarries

Coldspring has been operation under a series of contracts at the LSG and MBQ since the mid-1990s. Table 5.5-5 displays its annual production. In the last decade, the Forest monitored Coldspring operations for 54 days, with one observable issue in 2012: sediment runoff from a haul road was beginning to wash towards an adjacent forested wetland (figure 5.5-10). The quarry foreman was notified and the issue was corrected. All other inspections have been satisfactory. The following measures have occurred:

- Concurrent reclamation and planting completed in the gravel pit areas.
- Grout piled, (as detailed in the stipulation/mitigations attached to the contract),
- Accurate production reporting.
- Timely advanced payments.
- Stripped and stockpiled topsoil for reclamation purposes (figure 5.5-11).
- Adequate conducting of an intensive water quality-sampling program initiated in 2014, from the 2013 MBQ Grout Pile Expansion EA,
- Submittal of annual reports for SNF review.

Table 5.5-5. Coldspring annual production

MESABI BLACK QUARRY			LAKE SUPERIOR GREEN QUARRY		
YEAR	NET CUBIC FEET	VALUE	YEAR	NET CUBIC FEET	VALUE
2006	83,811.10	$59,314.19	2006	17,153.70	$16,502.19
2007	76,159.90	$67,247.51	2007	19,429.40	$18,459.28
2008	101,237.23	$88,814.02	2008	15,041.69	$14,685.85
2009	71,366.59	$63,125.27	2009	12,083.69	$12,141.97
2010	56,931.79	$50,711.34	2010	6,111.02	$6,538.80
2011	96,427.11	$84,677.31	2011	17,172.80	$16,518.61
2012	102,378.79	$89,795.76	2012	2,851.66	$3,108.31
2013	127,275.91	$111,207.28	2013	10,643.50	$10,903.41
2014	141,812.44	$123,708.70	2014	338.54	$369.01
2015	108,016.20	$94,643.93	2015	15,212.11	$14,832.41
2016	120,520.33	$105,397.48	2016	0.00	$0.00
2017	92742.53	$81,508.58	2017	18540.02	$17,694.42
12 yr Totals	1,178,679.92	$1,020,151.37	12 yr Totals	134,578.13	$131,754.27

Figure 5.5-10. Sediment wash

Figure 5.5-11. Stockpiled topsoil

Implications: Exploration, Development, and Production

In summary, monitoring determined that exploration mitigation and best management practice followed requirements, aside from a few isolated incidents in the last decade. The respective sections above list specific examples. Monitoring verified the permitting of mineral exploration projects with appropriate mitigation and best management practices to protect forest resources.

Although monitoring identified some impacts such as the presence of NNIS, undermining of merchantable timber, noise from drilling operations, and limited access road rutting, these impacts were not detrimental to Forest resources and the issues are being, or were, corrected in a timely manner. Monitoring also verified the authorizing of development and production projects with appropriate mitigation and best management practices to protect forest resources. In addition, surface disturbance at gravel pits and quarries have not exceeded any threshold established by the applicable environmental analysis. Although some minor impacts occurred such as undermining of trees and disposal of material into standing timber, cooperative operators remediated these issues and did not violate the contract to the degree that would warrant contract cancellation and subsequent penalties.

This supports mineral exploration, development, and production on the SNF as multiple use activities that are compatible with other Forest uses. Current and cumulative monitored conditions are consistent with Forest Plan objectives, and current law and regulation. Permit operators follow operating plans but when unplanned or unanticipated issues develop, they cooperate with the Forest to resolve them. Throughout the last decade, SNF personnel regarding permitted minerals activities recommended no Forest Plan changes; all avoidance and mitigation measures were effective, and mostly followed as required by project authorization stipulations. This indicates that no change is necessary for exploration, development, and production authorization processes at this time.

Recommendations

All monitoring elements identified in the monitoring section of the Forest Plan should continue as described. Adding, "Proper location of occupancy as per standards identified in the operating plan and relevant project stipulations" as a recommended indicator for minerals projects.

The Forest should implement a focused soundscape study to better measure the natural background sound level enhancing modeling and predicting the effects of noise generated from minerals exploration, development, and production operations.

During past environmental analyses for hardrock exploration drilling projects, the public raised concerns regarding drill sump effectiveness and potential impacts to water quality. The Forest should develop a focused monitoring study to verify assumptions that ground water and adjacent surface water quality is not impacted over the long term.

The Forest does not monitor many mineral material quarries as often as required in the SNF 2850 supplement due to lack of personnel and other priorities. In the future, the Forest should use a monitoring crew to assist with quarry monitoring.

5.6 Non-native Invasive Species

The Superior National Forest has both terrestrial and aquatic non-native invasive species (NNIS- see USDA Forest Service 2018 for list of NNIS). This section covers terrestrial plant NNIS; invasive insects like gypsy moth are covered in the Insect and Disease section. This report addresses the monitoring question for NNIS in two subsections: NNIS abundance and NNIS control measures.

5.6.1 Species Populations Monitoring Question:

To what extent is Forest management contributing or responding to populations of terrestrial or aquatic non- native species that threaten native ecosystems?

NNIS Abundance

Non-native invasive species pose a threat to terrestrial and aquatic ecosystems on the SNF, and Forest management actions can cause them to spread and increase in abundance. Even in the event of no management action, NNIS continue to reproduce and increase in abundance, although often at a slower rate. Over the last 13 years, NNIS abundance has increased. This subsection describes the increase in abundance and its relation to Forest management.

The Forest Plan direction that drives this monitoring question comes from:

- D-WL-9: Native plants and animals dominate all terrestrial and aquatic ecosystems, with non-native plants and animals forming, at most, a minor component.
- O-WL-37: Reduce the spread of terrestrial or aquatic non-native invasive species that pose a risk to native ecosystems.

This monitoring question is relevant because NNIS can threaten the health of entire ecosystems and adversely affect many other resource management activities. Measuring the abundance of NNIS helps assess how much Forest management contributes to the increase of NNIS and can suggest whether measures to reduce the spread of NNIS are effective.

For terrestrial plant NNIS, the indicator is acres of NNIS infestations. This unit of measure is appropriate because it is a concise summary of NNIS abundance, and is easily trackable from year to year to gain an understanding of NNIS trends over time.

Results

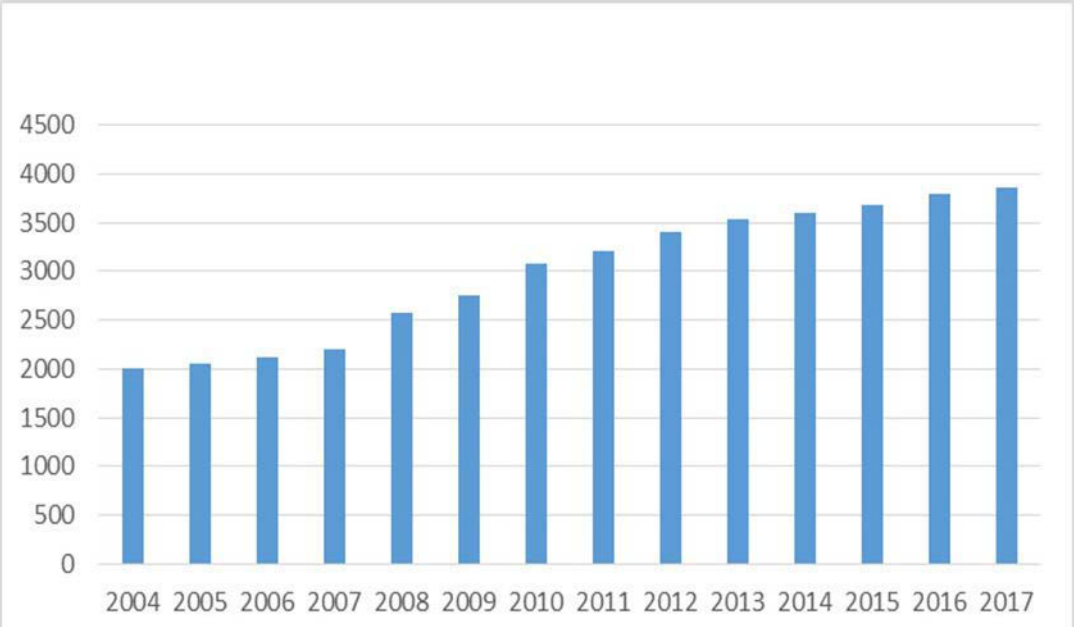
Terrestrial Plant NNIS

Figure 5.6-1 shows that terrestrial plant NNIS are increasing with time, between approximately 50 to 200 acres per year (NNIS increases from 2004 to 2010 represent increases due to inventorying NNIS in new parts of the Superior National Forest). Most species are the same shade-intolerant species that we began monitoring in 2006. There are relatively few known locations of the shade-tolerant species such as common buckthorn, garlic mustard, or Tatarian honeysuckle, but the numbers of garden valerian (also somewhat shade-tolerant) infestations are increasing rapidly. While the distribution of terrestrial plant NNIS is still predominantly along travel corridors, in the last 13 years this has shifted with more NNIS in upland disturbed sites like burned areas or clearcuts.

Both the Superior National Forest and local partners have had some successful early detections in the last 13 years that have kept new invaders from becoming well established; these include

plumeless thistle, Dalmatian toadflax, and marsh thistle. Other new invaders are close to the Forest (for example, Japanese barberry near Two Harbors, MN, and exotic *Phragmites* in southern St. Louis County), so these warrant continued work with partners on prevention and treatment efforts. Roadside infestations of reed canary grass have increased over the last ten years.

Figure 5.6-1. Acres of non-native invasive plants



Analysis

Terrestrial Plant NNIS

For terrestrial plant NNIS, current conditions generally meet Forest Plan direction. Figure 5.6-1 shows there has been an upward trend in NNIS acres over the last 13 years, but not a trend that looks like exponential growth. The largest infestations of non-native invasive plants are in wildfire-burned areas (e.g. Canada thistle in parts of the Pagami Creek fire burned area), recent harvest units, and forest roadsides, but native plant species still dominate terrestrial ecosystems which contributes to meeting D-WL-9.

In general, the spread of terrestrial plant NNIS has been relatively slow. Forest management contributes to terrestrial NNIS spread, but project-level mitigations act to slow down NNIS, as does implementation of an integrated pest management approach to invasive management that includes treatments, prevention actions, education, etc. Equally important are the heavily forested ecosystems of northeastern Minnesota that create a lot of shade and resist invasion from shade-intolerant invasives. Currently, shade-intolerant invasive plants like Canada thistle that establish after a disturbance such as a clearcut are a small proportion of the stand's vegetation. Such plants gradually stop flowering and making seeds when the canopy gets heavy enough to create shaded conditions at ground level. However, it is not clear how long they persist in this condition; it could be that they persist at much lower numbers for quite some time until the next disturbance, when they can take right off even more rapidly than the first invasion cycle. With future climate trends and potential changes in forest composition and larger wildfires, there is a

risk for large increases in NNIS in the future, as well as introductions of new non-native invasive plants from adjacent regions like Wisconsin or southern Minnesota.

Shade tolerant invasive plants like common buckthorn are not abundant on the Superior National Forest yet, but they are a huge concern given the impacts they have caused to forest ecosystems elsewhere in the Midwest. Inventories for new infestations are high priority to detect infestations early.

Unlike in other parts of the U.S., the Superior National Forest has not yet experienced the heavy levels of terrestrial plant NNIS invasion that cause dramatic changes in ecosystem function, such as increased erosion or changes in fire frequency. Where there are locally heavy infestations (e.g. hawkweed along a roadside) that drastically alter native plant community composition, ecosystem effects are generally quite localized and related as much to whatever ground-disturbing activity that caused the weed infestation as to the weed infestation itself. Some plant invasions occur with changes in soil processes, but on the Superior National Forest, any changes in soil processes are probably more associated with non-native earthworm activity than the non-native invasive plants. Of course, the fact that the Superior has not had heavy NNIS invasion yet makes our ongoing NNIS management all the more critical.

Recommendations

The Forest should continue the process of inventorying and monitoring terrestrial plant NNIS. In the future, there should be increased emphasis on inventorying forest stands for shade tolerant invasives like common buckthorn and Tatarian honeysuckle, especially near populated areas that have buckthorn (likeEly, Aurora, or Chisholm) to detect invasion early. The Forest needs to observe how long shade-intolerant invasive plants persist in a non-flowering state in a shaded forest understory. Finally, there is a need for research for unmanned aerial systems to accomplish this inventory and monitoring task so implementation of Forest Plan direction on invasives can continue and become more efficient.

5.6.2 Control Ecosystems Monitoring Question:

To what extent is Forest management contributing or responding to populations of terrestrial or aquatic non- native species that threaten native ecosystems?

NNIS Control Measures

NNIS abundance s directly relates to the topic of this section, NNIS control measures. Control measures, when available and applicable, are an important management action that can slow the spread of widespread NNIS or eradicate small infestations of new NNIS invasions. These control measures can serve to offset increases in NNIS abundance.

The Forest Plan direction that drives this monitoring question comes from O-WL-38: Use integrated pest management to:

(a) Eradicate any populations of new invaders.

(b) Contain or eradicate populations of recent invaders.

(c) Limit the spread of widespread, established invaders within the planning area.

This monitoring question is appropriate because NNIS can threaten the health of entire ecosystems and negatively affect many other resource management activities. The driver (O-

WL-38) provides general direction on how to manage invasive species. Together, these help address the question of what and how much is the Forest doing to combat NNIS in an integrated manner. Not only does this demonstrate to the public and partners that we use multiple approaches to manage invasive species, but this element is also useful in project level cumulative effects analysis.

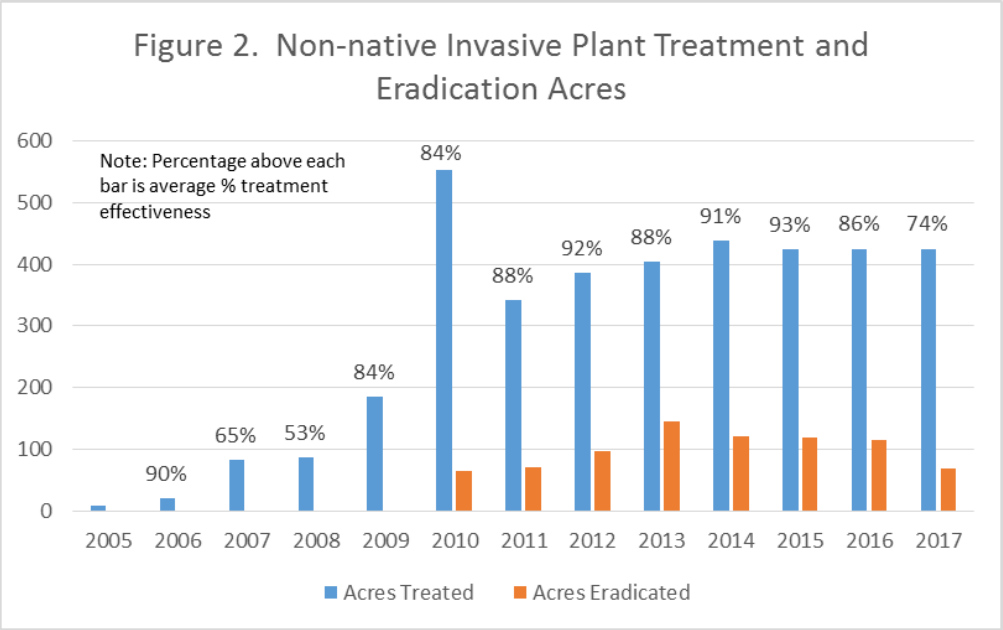
The indicator selected is acres of NNIS control measures and treatment effectiveness. This indicator is a concise summary of how effective the Forest has been at managing NNIS. Efforts to control NNIS are a concrete Forest management response to NNIS populations that directly address the monitoring question. The control measures allow for easy tracking from year to year to gain an understanding of NNIS trends over time.

Results

Figure 5.6-2 shows a gradually increasing trend in acres of terrestrial plant NNIS treated over the last 13 years, with the exception of 2010 when a pulse of extra ARRA funding allowed for additional accomplishment. These acres represent sprayed, mowed, pulled, or treated with a biological control insect for terrestrial plant NNIS.

Figure 5.6-2 also shows the average annual treatment effectiveness. The percentage above each bar represents the effectiveness of management actions taken against NNIS. Most years show better than 80 percent control.

Figure 5.6-2. Non-native invasive plant treatment and eradication acres



Lastly, figure 5.6-2 shows the acres of terrestrial plant NNIS eradicated annually since 2010. When a site visit to a treated infestation in a subsequent year shows no remaining infestation, then the infestation is marked as eradicated. Monitoring shows 80-130 acres of NNIS eradicated annually.

Analysis

After building capacity and program support for treating invasive plants over the last 13 years, the progress in meeting O-WL-38 has remained steady for the last five years. Unfortunately, while control efforts help limit spread, more terrestrial plant NNIS are spreading than are eradicated annually. Because every ground-disturbing project has potential to spread NNIS, invasive plant management efforts are never going to be "done." For widespread NNIS, desired condition D-WL-9 describes the best outcome: NNIS are a minor component of terrestrial ecosystems.

Yet to the best of our knowledge, our approach to prioritizing treatment efforts has prevented highly aggressive NNIS with limited distributions from expanding their infestations. Annual control efforts for such species as common buckthorn, leafy spurge, and purple loosestrife have kept infestations in check or eradicated them.

Effectiveness monitoring shows that our implemented control efforts are successful. We are averaging 85 percent control or better over the last several years, and eradicating small infestations. The Forest has not eradicated any large infestations, but control efforts have prevented flowering, seed production, and shrunk the infestation in some large terrestrial plant NNIS infestations.

Forest staff performs all control efforts in the context of an integrated pest management approach. Although not described here, outreach, prevention, inventory, restoration, and partnership efforts are ongoing and are critical to the success of the control efforts.

Recommendations

The Forest should continue the process of monitoring NNIS control efforts.

References

USDA Forest Service. 2018. Non-native plants and animals known from the Superior National Forest. 2 p. Administrative report in project record. On file with Forest Supervisor, Superior National Forest, 8901 Grand Ave. Pl., Duluth, MN 55808.

5.7 Cooperation

The Forest works cooperatively with other landowners and land managers to protect, enhance, and restore physical and biological resources, as well as social and economic values. Cooperative management includes tribal, state, county, local governments, as well as other Federal agencies.

The Forest continues to emphasize agency, tribal, and public involvement with increases in inter-governmental coordination with federal, state, county governments and agencies; a high level of communication and dialogue with a broad range of stakeholders; and successful dialogue between Tribal governments and Superior NF officials.

In cooperation with other government agencies and private organizations, the Forest provides support for national forest, state, and National Scenic Byways to enhance the byway's scenic resource, provide recreation and interpretive opportunities, address resource issues, and promote economic development.

5.7.1 Cooperation Monitoring Question:

To what extent does the Forest emphasize agency, tribal, and public involvement and inter-governmental coordination with federal, state, county governments and agencies?

Monitoring Indicators:

- Number of formal agreements by type
- Dollar value of cash, goods, and services included in formal agreements
- Hours of volunteer service at an appraised value
- Dollar value of donations

Table 5.7-1. Cooperation report by agreement type for 2009-2017

Monitoring Activity Measured Agreements by Type	Number of Agreements	Number of Modifications	Total Actions	Total $ Value	Total $ Value to USFS
Collection Agreement	100	53	153	9,268,705	8,283,828
Challenge Cost Share	88	74	162	7,847,943	3,884,161
Fire	46	194	240	3,388,433	2,185,799
Inter-Agency (federal)	64	89	153	1,657,174	1,116,963
Law Enforcement	7	21	28	293,471	NA
Memorandum of Understanding	20	1	21	NA	NA
Participating Agreement	76	65	141	8,334,205	2,157,977
Roads Agreement	1	NA	1	20,004	15,204
Cooperative Agreement	1	NA	1	20,008	NA
Stewardship Agreement	3	2	5	488,850	141,272
Domestic Grant	2	NA	2	42,475	5,000

Good Neighbor	1	2	3	527,444	43,631
Total	409	501	910	31,888,712	17,833,835

Formal Agreements:

Tables 5.7-1 and 5.7-2 provide information relating for the:

- Number of formal agreements by type.
- Dollar value of cash, goods, and services included in formal agreements.

Table 5.7-2. Cooperation report for 2009-2017 by year

Fiscal Year	Number of Agreements	Number of Modifications	Total Actions	Total $ Value	Total $ value to USFS
2017	35	57	92	4,504,884	2,001,868
2016	53	56	109	4,048,725	2,341,549
2015	45	46	91	2,960,689	1,842,200
2014	47	68	115	3,681,312	2,280,257
2013	67	43	110	4,556,462	3,478,475
2012	32	91	123	1,733,669	1,242,499
2011	44	61	105	2,363,573	844,431
2010	40	42	82	5,443,697	2,381,841
2009	46	37	83	2,595,701	1,420,718
Total	409	501	910	31,888,712	17,833,838

Figure 5.7-1. The Forest Service enters into different types of agreements in their work with others

- The Forest Service uses many types of agreements to document its work with others. Each of these has specific Congressional legal authority and requirements. The appropriate instrument depends on what the partnership will accomplish, who will benefit, and who is providing funding. The Forest Service must have appropriate statutory authority prior to entering into any agreement, which could result in the use, obligation, or other commitment of any Forest Service resources.

Collection Agreements Definition: Used for the FS accepting money from a non-federal party to carry out a purpose authorized by law. Common NFS Authorities used include the:

- Cooperative Funds Act of June 30, 1914, which allows the Forest Service to accept cash contributions to work on Forest Service projects that benefit the national forests (advance or reimbursable payment).
- Granger-Thye Act of April 24, 1950, Section 5, which allows the Forest Service to collect funds to perform work for the cooperator's benefit for work related to administration, protection, improvement, restoration, etc. of lands within or near NFS lands, and there is a public benefit.

Table 5.7-3. Partners using collections agreements on the SNF

Partners List		
1854 Treaty Authority	Eastern National	MN Power and Light
American Forests	Encampment Minerals, Inc	National Forest Foundation
Arbor Day Foundation	Fond du Lac Reservation	Polymet Mining
City of Babbitt	Friends of the Boundary Waters Wilderness	Regents of the University of MN
City of Hoyt Lakes	Iron Range Resources Rehabilitation Board	Sawbill Canoe Outfitters
Cold Spring Granite Company	Lake County	Seppi Brothers Concrete Products
Cook County	Lake Vermilion Resort Association	South Birch Lake Cabin Owners Association
Cook County Visitors Bureau	Lutsen Tofte Tourism Association	Sugarloaf:
Crane Lake Sustainable Land Corporation	MN Deer Hunters Association	Trail Prospectors Alliance
DMC (USA) LLC	MN DNR Enforcement	Twin Metals
Duluth Metals Corporations	MN DNR; Division of Parks and Trails	

Figure 5.7-2. Cooperative agreements are one of the ways the Forest Service accomplishes mutually beneficial work

- **Challenge Cost Share:** Used when the Forest Service cooperatively develops, plans, and implements projects with other parties that are mutually beneficial to the parties and that enhance Forest Service activities. Mutual interest and mutual benefit, in the same qualitative way, are required, as are matching funds (minimum match 20 percent). Common NFS Authorities used include: Interior and Related Agencies Appropriations Act of 1992 (P.L. 102-154) which authorized the Challenge Cost Share Program permanently for all Forest Service programs; and the Secure Rural Schools and Community Self-Determination Act of 2000.

Table 5.7-4. Partners using Challenge Cost Share agreements on the SNF

Partners List		
Arrowhead Regional Development Commission	International Mountain Bicycling Association	Sugarloaf: The North Shore Stewardship Association
Banadad Trail Association	Iowa State University of Science and Technology	Superior Cycling Association
Bear Track Outfitting Co	Iron Range Off-Road Cyclists	Superior Timber Wolves Sportsman Club
Bernie's Road Association	Lake Vermilion Resort Association	The Gunflint Trail Historical Society
Boy Scouts of America, Sioux Council	Lutsen Trailbreakers	The Nature Conservancy
Ce Tempoxcalli	MN DNR	The Ruffed Grouse Society
Colorado State University	North House Folk School	University of MN
Conservation Corps	North Superior Ski and Running Club	University of Wisconsin-Eau Claire

Partners List		
Arrowhead Regional Development Commission	International Mountain Bicycling Association	Sugarloaf: The North Shore Stewardship Association
Cook County Snowmobile Club	Northwoods Volunteer Connection	Voyageurs National Park Association
Fond du Lac Reservation	Saint Louis County Schools	Wartburg College
Friends of the Boundary Waters Wilderness	South Kawishiwi Cabin Group, LLC	Wolf Lake Citizen Monitoring Group
Gunflint Trail Association	Sportsmen's Club of Lake Vermilion, INC.	Wolf Ridge Environmental Learning Center
Ind School District 621	Sugarbush Trail Association	

- **Fire**: Specialized agreements used to document cooperation and funding between the FS and other specific parties for cooperative fire agreements.

Table 5.7-5. Partners using fire agreements on the SNF

Partners List	
Brimson Area Volunteer Fire Department	Maple Hill Volunteer Fire Department
City of Aurora	MN DNR
Finland Volunteer Fire Department	

- **Interagency Agreements:** Used when one Federal agency is in a position to provide materials, supplies, equipment, work, or services of any kind that another agency needs to accomplish its mission. Interagency agreements use authorities from the Economy Act of June 30, 1932 (P.L. 97-258 & 98-216), and the Service First Authority.

Table 5.7-6. Partners using interagency agreements on the SNF

Partners List	
Buffalo River National Park Service	U.S. Department of Interior (USDI), Fish & Wildlife Service
Grand Teton National Park	USDI Geological Survey
National Park Service, Midwest Region	USDI National Park Service
U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service	U.S. Department of Agriculture, Natural Resource Conservation Service
U.S. Department of Commerce, National Oceanic Atmospheric Agency (NOAA) National Weather Service	U.S. General Services Administration (GSA) Property Disposal

- **Memorandum of Understanding (MOU):** Used to document a framework for cooperation between the Forest Service and other parties for carrying out their separate activities in a coordinated and mutually beneficial manner where nothing of value transfers between parties. No special authority required to use a MOU.

Table 5.7-7. Partners using MOUs on the SNF

Partners List		
Bois Forte Band of Chippewa for Tribal Use of Campgrounds	Gunflint Trail Association	North St. Louis Soil & Water Conservation District
Carlton County for Radio Frequency Sharing	Lake County	Quetico Provincial Park
City of Hibbing Fire Department for Radio Frequency	Lake County for Radio Frequency	St. Louis County for Radio Frequency
Coalition of Recreational Trail Users for Trail Map MOU	Laverendrye Provincial Park	South St. Louis County
Cold Spring Granite Company for Mesabi Black Dimension Stone Quarry Grout Pile Expansion	MN Deer Hunters Association for MOU	State of MN for the Airnet Radio Frequency Agreement
Cook County for Radio Frequency Authorization	MN Department of Agriculture	Sugarloaf: The North Shore Stewardship Association
Cook County Snowmobile Club for Winter Monitoring in the BWCAW	MN Department of Natural Resources (MNDNR) for Cook County Invasive Team	The Nature Conservancy
Cook County Soil and Water Conservation District	MN Department of Transportation (MNDOT)	U.S. Customs and Border Protection for Radio Frequency
Fond du Lac Band of Lake Superior Chippewa for Tribal Use of Campgrounds	MN DNR	USDI National Park Service (NPS)
Grand Portage Band of Lake Superior Chippewa for Tribal Use of Campgrounds	MN DNR for MN DNR BWCAW MOU	USDI NPS, Voyageurs National Park, Grand Portage National Monument and MNDNR for Sister Sites Arrangement
Grand Portage National Monument	MN DOT for Lake County Invasive Team	USDI NPS, Voyageurs National Park, and Grand Portage National Monument for Sister Sites Arrangement
Grand Portage Reservation Tribal Council	MN DOT for MN DOT Armer Radio System	Wolf Ridge Environmental Learning Center
Grand Teton National Park for Grand Teton NP Cross Designation	MN DOT for St. Louis County Cooperative Weed Management Area (CWMA)	

Figure 5.7-3. Singing of the Sister Sites Arrangement, 2011 (from left to right) Tim Cochrane, Grand Portage National Monument Superintendent; Robin Reilly, Quetico Provincial Park Superintendent; Lynda Horman, LaVerendrye Provincial Park Superintendent; Jim Sanders, Superior National Forest Supervisor; Michael Ward, Voyageurs National Park Superintendent

- **Participating Agreement:** Use authorities from: Cooperative Funds and Deposits Act of 1975 (P.L. 94-148); Wyden Amendment (P.L. 111-11); and Secure Rural Schools and Community Self-Determination Act of 2000

Table 5.7-8. Participating agreement entities on the SNF

Partners List		
1854 Treaty Authority	Fairbanks Township	South St. Louis County
Arrowhead Economic Opportunity Agency, Inc	Friends of the MN Conservation Corps	St. Louis County
Conservation Corps	Great Lakes Aquarium	Student Conservation Association, Inc
Cook County	Gunflint Trail Association	Sugarloaf: The North Shores Stewardship Association
Cook County Soil and Water Conservation	Lake County Developmental Achievement Center Inc.	Tentmakers Inc
Dave Piepgras	MN DNR	University of Minnesota
Dovetail Partners Inc	Northern Bedrock Conservation Corps	University of Wisconsin-Eau Claire
Eastern National	Partners using Participating agreements on the Superior National Forest: Lake County	White Iron Chain of Lakes Association, Lake County
Eldercircle		

Roads Agreement: Specialized agreements used to document cooperation and funding between the FS and other specific parties for cooperative road agreements. The following partner uses this participating agreement on the Superior National Forest.

- MN DNR

Cooperative Agreement: The following partner uses this cooperative agreement on the Superior National Forest:

- Cook County Visitors Bureau

Stewardship Agreement: (Authorities used Stewardship End Result Contracting (P.L. 108-7). The following partner uses the Stewardship Agreement on the Superior National Forest:

- The Nature Conservancy

Domestic Grant: The following partners use the Domestic Grant Agreement on the Superior National Forest:

- City of Ely
- Superior Cycling Association

Good Neighbor Agreement: The following partner uses the Good Neighbor Agreement on the Superior National Forest:

- MN DNR

Figure 5.7-4. Working with volunteers is a great value for the SNF

Volunteers:

The volunteer's indicator is hours of volunteer service at an appraised value.

Table 5.7-3 provides information on hours of volunteer service at an appraised value. The USDA Forest Service Volunteer & Partners Accomplishment Report (Reference FSM 1800) Report No. FS-1800-AR provides the information for the Superior National Forest[1].

Table 5.7-9. Hours of volunteer service at an appraised value

Fiscal Year	Accumulated Hours of Volunteers	Person Years	Female	Male	Total Appraised Value of Volunteers Time ($)	Total Value of Partners expenses[2] ($)	Total Dollar Value[3] ($)
2017	38,796	22	242	659	936,535	29,625	1,054,020
2016	37,527	21	223	479	884,148	38,445	1,016,273
2015	29,503	16	227	455	680,625	18,632	811,872
2014	28,956	17	150	427	652,958	5,270	701,724
2013	28,387	16	100	140	628,488	12,480	663,189
2012	50,767	28	222	420	1,106,224	NA	1,128,027
2011	28,651	16	141	360	611,996	NA	629,690
2010	NA	20[4]	NA	NA	NA	NA	NA
2009	NA	22[5]	NA	NA	NA	NA	NA

Work donated by volunteers supports many facets of the U.S. Forest Service and the Superior National Forest. The following shows the approximate value of time donated in a number of categories.

Trail maintenance and construction (wilderness and non-wilderness) attracts the highest amount of volunteer time and had a value of over **three million dollars** (~ $3,399,000) between 2011 and 2017 for an average of **$486,000 per year.**

Program categories in the years 2011 through 2017 where volunteer provided time and had[6]:

- **Over $100,000** value of volunteer time:
  - Trail maintenance and construction (wilderness and non-wilderness) $3,399,000

[1] Report was available for the years 2011 through 2017 and included these programs: Youth Conservation Corps (FSM 1840); Partnerships and Organization Agreements (FSM 1810 and 1820); International Visiting Volunteers (FSM 1830) US Forest Service JCCCC (FSM 1850) and Individual and Group Volunteers (FSM 1830)

[2] Participant Wages/ Materials/ Supplies/Equipment/Vehicles/Admin/Training (Does not include value of volunteers time)

[3] Includes value of volunteers time and other expenses from partners and USFS

[4] Used data from the RO "YVH_Yearly_comparison_2002-2010"

[5] Used data from the RO "YVH_Yearly_comparison_2002-2010"

[6] Included all types of work that had a volunteer hour appraised value of over $10,000 in a fiscal year from 2011 to 2017

- Recreation (developed & dispersed) resource maintenance & improvement: $318,000
- Snowmobile/ski trail grooming: $ 212,000
- Campground hosts/facility caretakers: $138,000
- Volunteer coordination / non-profit boards / partnerships: $135,000
- Archives, excavation, site surveys, monitoring, stabilization and tours: $123,000
- Backcountry/front country patrols (recreation management): $119,000
- Wilderness management (monitoring, site surveys, condition reports): $119,000

- **Over $50,000** value of volunteer time:
  - Water/soil improvements and stewardship projects: $77,000
  - Heritage facility projects: $63,000
  - Threatened and endangered species monitoring, surveys, and protection: $59,000
  - Front desk/public information/visitor services: $54,000
- Between $10,000 and $50,000 value of volunteer time:
  - Reforestation, rehabilitation, restoration, and monitoring: $49,000
  - Campground maintenance: $46,000
  - Administrative/business operations support: $44,000
  - Conservation education /interpretation: $26,000
- Stand Improvement $21,000
  - Design, construction, maintenance, and improvement of facilities: $21,000
  - Botanical gardens, rare plant surveys, monitoring protection: $19,000
  - Geographic information systems, geospatial data, website support: $15,000
  - Misc. forest products and timber/salvage sales: $14,000
  - Forest and grassland stewardship and restoration: $11,000

Donations:

Table 5.7-10 provides information for the dollar value of donations indicator.

There was $194,833 donated to the Superior National Forest according to existing records. Almost all is from two donations of property.

Table 5.7-10. Dollar value of donations

Fiscal Year[7]	Donation amount of fund ($)s	Donation value of lands($)	Total donation of funds($)
FY17	97		97
FY 16	196		196
FY15	176	90,000	90,176
FY14	99		99
FY13	265		265
FY12		104,000	104,000

[7] The Forest has records from FY13 through FY17 for financial donations; there are not figures from prior years.

- In 2012, there was 4.2 acres of land on Green Stone Lake, Lake County in the Kawishiwi Ranger District, Rom #4553 valued at $104,000. This parcel contributes towards existing recreational opportunities in nearly primitive surroundings and as it is adjacent to the wilderness boundary; it enhances and protects the character of the Boundary Waters Canoe Area Wilderness. Furthermore, it promotes effective management of the forest by consolidating boundary lines.
- In 2015, there was 28 acres of land that borders Moose Lake, St. Louis County in the Laurentian Ranger District, Wetlands America Trust, Inc. #4559 valued at $90,000. This parcel borders a wild rice lake heavily visited by waterfowl. The lake experiences high public use, particularly by wild rice gatherers, duck hunters, and trappers. All other land surrounding the lake is National Forest System land and managed for natural resources and recreation opportunities.

Recommendations

The Superior National Forest should continue to utilize the full range of agreement options is has in the past. The Forest should continue to maintain and enhance the dollar and relationship values it as developed through its cooperation and partnership efforts.

5.8 Research Needs

The Forest Service research program provides the scientific basis for the management, protection, and use of the Nation's national forests, including wilderness. Research needs appropriate to management of the Boundary Waters Canoe Area Wilderness (BWCAW) are identified in chapter 3, appendix B of the Superior National Forest Land and Resource Management Plan (Forest Plan). Further, the SNF Forest interdisciplinary team meets on a regular basis and discusses research needs both inside and outside the BWCAW.

The program developed for research reflects a commitment to develop and disperse technical knowledge to resolve problems associated with wilderness and forest management. It will also provide a better understanding of the ecosystems that make up the Superior National Forest.

5.8.1 Research Implementation and Opportunities Monitoring Question

Determine research implementation progress and opportunities. Revise needs and priorities of research.

To track how well research conducted on the Superior National Forest meets the needs of resource managers, indicators are used.

- Research topics and management questions identified by the Forest interdisciplinary team and in the Forest Plan: The Forest interdisciplinary team meets on a regular basis and records any research topics or management questions identified by the group. Additionally, chapter 3, appendix B of the Forest Plan identifies research needs associated with the BWCAW.
- Number and subject of research permits issued on the Forest: The Superior National Forest has a comprehensive application process for research permits Researcher wishing to conduct a project must first fill out a research permit application that circulates to Superior NF program managers for review. The final approved permit incorporates suggestions for improving the research methodology to meet Superior NF goals and terms of conditions. Research projects conducted within the BWCAW must got through a separate permitting and review process.

Results

Results are presented for the BWCAW first, followed by results for non-wilderness areas of the Forest. Research topics and management questions are organized by subject area.

The Forest Plan identifies the following research needs for the BWCAW:

Cultural Resources

- Develop quantitative methods of measuring erosion rates and new elements (such as ecological land type phase (ELT) and soil compaction) to include in Limits of Acceptable Change indicators. This will aid in performing cultural resource site monitoring.
- In addition, develop a method of monitoring using permanent camera points to visually record site effects.

Soil, Air and Water Resources

- Assess level 3 erosion loss code used in the Limits of Acceptable Change review and its correlation to the level of allowable soil loss on each ELT.

- Assess whether added nutrients and potential pollutants that accumulate over time near campsites have significant impact on water quality or site conditions.
- Develop a method for simplified environmental monitoring to detect presence/absence or concentration of giardia cysts in BWCAW surface waters.
- Develop refined methods of assessing significance of impacts from existing and proposed sources of air pollutant emissions on air quality related wilderness values.

Fire

- Monitor fires to enhance predicting fire behavior of wildfires and prescribed fires.
- Monitor post-fire effects to the BWCAW ecosystem to ensure that the the Forest is meeting objectives of the prescribed fire program.
- Determine the social reaction to and acceptance of the prescribed fire program both during and after a fire.
- Develop models that would address high fuel load areas and prescribed fire effects on plant communities.

Wildlife and Fish

- Determine the impacts on eagles, loons, and other wildlife from fish remains on rocks by anglers.
- Monitor contaminant levels in fish and fish-eating wildlife.
- Determine whether angler harvest affects natural lake trout populations.
- Determine bear population dynamics in the BWCAW, including movement of bears to- and-from Ontario and adjacent areas of Minnesota.
- Develop techniques for minimizing bear/human conflicts in the BWCAW.
- Develop an ecological classification system for lakes.

Plant Community

- Determine what role insect and disease, fire, and windstorms play in the natural ecosystem of the BWCAW,Superior National Forest, and Quetico Provincial Park. For example, what type of fire (intensity and frequency) influenced natural vegetation?
- Develop wilderness baseline vegetative studies.
- Establish a list of plants native to the wilderness and northeast Minnesota that would be suitable for revegetating campsites and nursery grown.
- Develop a list of indigenous plants that are resistant to high use situations and that match ELT conditions.
- Continue to refine the ecological vegetation communities (using ecological classification) that exist in the BWCAW.
- Determine how the BWCAW fulfills neotropical migrant bird species habitat.
- Determine the Forest's old-growth distribution and compare it to the old-growth distribution in the BWCAW.
- Determine distribution, abundance, and habitat associations of sensitive animal species occurring in the BWCAW.
- Determine if animal use patterns and corridors link to 'outside BWCAW' areas and if it is adequate.

Social

- Assess impacts of visitor use of the BWCAW and further define 'crowding,' in relation to its effect on visitors seeing other visitors and their wilderness experience. Refine educational messages and methods to ensure protection of the resource by evaluating wilderness education and face-to-face wilderness education.
- Develop a reliable method to monitor off-season (Oct.1-April 30) use and use permits.
- Determine visitor trends and analyze likely changes. Determine any increase in destination-type trips and their potential consequences on travel zones.
- Determine if displacement of visitors from the BWCAW to Quetico is occurring, why, and how often.

Between 2015 and 2017, the Forest issued twenty-eight research permits for studies conducted in the BWCAW.

Table 5.8-1. BWCAW research permits, 2015-2017

Researcher	Topic
2015 Permits:	
Duluth Archaeology Center and University of Minnesota--Duluth	Geoarchaeology Investigation at the Knife Lake Quarries
Minnesota Department of Natural Resources	Survey of the Border Lakes ECS Subsection
The Wilderness Classroom/Northeastern Minnesotans for Wilderness	Water quality, micro-plastics and group encounter monitoring
Minnesota Department of Natural Resources	Forest Inventory and Analysis
Minnesota Pollution Control Agency	Lake Water Quality Assessment Program
Minnesota Pollution Control Agency	Water quality monitoring of 3 heavily used recreational lake in the BWCAW
Minnesota Pollution Control Agency	Intensive Watershed Monitoring Program
Natural Resources Research Institute	Surface Water Assessment FY 15
University of Minnesota – Twin Cities	Assessing Native American Impacts on the Proto-Historic Fire Regimes of Lac La Croix
University of Minnesota – Twin Cities	Moose forage quality, climate change
University of Minnesota—Twin Cities	Central Arrowhead County Geologic Atlas
US Geological Survey	Superior National Forest Wolf-Deer Study
2016 Permits:	
Minnesota Department of Natural Resources	Forest Inventory and Analysis
Minnesota Department of Natural Resources	Survey of the Border Lakes ECS Subsection
Minnesota Pollution Control Agency	Wetland Assessment

Researcher	Topic
Natural Resources Research Institute	Avian Response to Pagami Creek Fire
Natural Resources Research Institute	Surface Water
US Geological Survey	Superior National Forest Wolf-Deer Study
University of Minnesota--Duluth	Geology of Wilder Lake Intrusion in Pagami Creek burn area
University of Wisconsin-Platteville	Ojibwe land-use
2017 Permits: Minnesota Geological Survey, University of Minnesota – Twin Cities	Geologic Mapping in the Arrowhead Area
Minnesota Department of Natural Resources	Forest Inventory and Analysis
Minnesota Department of Natural Resources	Minnesota Biological Survey (MBS)baseline Survey
Minnesota Pollution Control Agency	National Lakes Assessment
Independent, Fishes of MN	Lake Surveys for Northern Sunfish
University of Minnesota – Twin Cities	Carbon and nitrogen cycling under ecto- and arbuscular mycorrhizal tree species in a boreal forest system
University of Minnesota – Twin Cities	Environmental and genetic passportization of cloudberry on the southern borders of the European and North American area
US Geological Survey	Superior National Forest Wolf-Deer Study

Table 5.8-2 classifies the twenty-eight permits issued within the BWCAW into specific subject areas. Some permits fall under more than one category:

Table 5.8-2. BWCAW research permits by subject area

Subject Area	Number of Permits
Cultural Resources	2
Soil, Air and Water Resources	8
Fire	2
Wildlife and Fish	6
Plant Community	8
Social	1
Geology	4

Every research subject area listed in the Forest Plan had at least one permit associated with it. Though not listed in the Forest Plan, the subject of geology had multiple permits issued between 2015 and 2017.

The Forest interdisciplinary staff and SNF staff identified the following research needs and management questions for non-wilderness areas outside the BWCAW. :

Soil, Air and Water Resources

- What are the critical nitrogen loads for terrestrial and aquatic systems on the Forest?
- Can we develop a long-term soil productivity study to see how vegetation management activities (i.e. harvest, harvest with slash reduction relating to fuel concerns, Rx burning, etc.) are affecting the resource?
- Can we develop a more robust soil organic carbon model for the Forest?

Fire

- Are Bud Heinselman's mapped fire regimes accurate or was he just mapping extreme events? How do we account for the spectrum of fire severity and activity that occurs on the Superior NF?

Wildlife and Fish

- Does noise from minerals exploration activities such as drilling negatively impact wildlife on the Superior NF? Are particular species sensitive to these types of activities?
- How long after reclamation, do temporary roads and drilling pads related to minerals exploration have impacts that might affect wildlife? What would be good indicators to monitor?
- Can we perform a comprehensive survey of pollinator species on the Superior NF?
- What is the extent of the invasion and impacts of non-native earthworms on the Forest?

Plant Community

- Are silviculture herbicide prescriptions effective?
- Can we perform a comprehensive survey of pollinator habitat on the Superior NF?
- How are non-native invasive plants affecting productivity and efficiency of management actions on the Superior NF?
- Is competition from brush and grass species affecting regeneration of tree species on the Forest?

Social

- What are the impacts of mining activity on the Superior to recreation-based businesses in the surrounding communities? Can we use existing local economies as a baseline?
- What is the availability of biomass on the Forest and what are sustainable production levels? How can these product impact local economies? What are the impacts to soils and other resources on the Forest?

Climate Change

- What shrub species could increase or decrease in abundance with climate change? Particularly, what is the model prediction for hazel?
- Can we expand on experimental plantings of different species and genotypes on the Superior to begin assessing success rates in a broader range of plant communities?

- How effective are the adaption actions for climate change that we perform at mitigating risk and creating resiliency?
- How will warming winters affect resources on the Superior NF? What will be the implications for management?
- Are Forest Plan outlined desired future conditions still relevant with the predicted changes in climate?

Table 5.8-3 shows the forty-six research permits issued for studies conducted on the Superior NF during 2015 and 2017, outside the BWCAW.

Table 5.8-3. Permits issued for studies conducted on the Superior National Forest during 2015-2017, outside the BWCAW

Researcher	Topic
2015 Permits: Iowa State University	Vegetation Fuel Mapping
Kansas State University Department of Geography	Influence of transport processes in the catchment and lake on geochemical composition of lake sediments in northern MN
Minnesota Department of Health	Assessing the acarological risk of human exposure to tick-borne pathogens in Minnesota
The Nature Conservancy	Adaptation Forestry in Minnesota's Northwoods
The Nature Conservancy	Vegetation and Fuels Mapping Pilot Project
Natural Resource Research Institute, University of Minnesota, Duluth	Giant River Fluke and Lymnaeid snail host
Natural Resource Research Institute, University of Minnesota, Duluth	Genetics of the threatened arctic disjunction *Euphrasia hudsoniana* var. *ramosior*
University of Minnesota—Twin Cities	Peatland Baseline Plots for the Polymet Site
University of Minnesota and Texas Tech Collaboration	Long-term Community Dynamics of Small Mammals on the Superior National Forest
University of Washington	Carbon Monitoring System (CMS)
U.S. Geological Survey	Environmental geochemical signatures of covered mineral deposits in the northern midcontinent
U.S. Geological Survey, Minnesota Water Science Center	Assessing the Influence of Natural Copper-Nickel Bedrocks On Water Quality
2016 Permits: Independent, University of Minnesota and Texas Tech	Range extension of White-footed Mouse
Kansas State University	Geochemistry in lake sediments

Researcher	Topic
Minnesota Department of Natural Resources--Minnesota Biological Survey (MBS)	Survey of the Laurentian Mixed Forest
Minnesota Geologic Survey (MGS)	Central Arrowhead County Geological Atlas
Minnesota Forest Resources Council	Biochar application and Jack Pine physiology
Minnesota Department of Natural Resources	Spruce Grouse
Minnesota Department of Natural Resources	Moose Calf Population
Minnesota Department of Natural Resources	Moose Winter Study
Minnesota Pollution Control Agency	Intensive Watershed Monitoring Program
Natural Resource Research Institute, University of Minnesota, Duluth	National Forest Bird Monitoring Project (NFB)
Koochiching Soil and Water Conservation District	2015 North St. Louis Surface Water Assessment
The Nature Conservancy	Adaptation Forestry in MN Northwoods
US Geological Survey	Geochemical Signatures of Minerals
University of Minnesota--Duluth	Coastal Arctic Plants and Climate Change
University of Minnesota--Duluth	Origin of Granite in Vermillion Granitic Complex
University of Minnesota—Twin Cities	Peatland survey around Polymet site
University of Wisconsin - La Crosse	Causes of High Mercury in Fish
Research Permits Issued: 2017	
2017 Permits: Independent, University of Minnesota and Texas Tech	Documentation of Range Extension of the White-footed Mouse
Independent, University of Minnesota and Texas Tech	Eastern Heather Vole Habitat and Response to Prescribed Burns
Independent, University of Minnesota and Texas Tech	"Missing" Rock Voles on SNF
Independent, University of Minnesota and Texas Tech	Long-Term Community Dynamics of Small Mammals on SNF
Cleveland of Museum of Natural History	Boreal Birds of North America: Evolutionary History

Researcher	Topic
Minnesota Geological Survey, University of Minnesota – Twin Cities	Bedrock Geologic Mapping in the Arrowhead Area
Minnesota Geological Survey, University of Minnesota – Twin Cities	Southeastern Arrowhead County Geological Atlas, Part A
Minnesota Department of Natural Resources	Minnesota Biological Survey (MBS) baseline Survey
Minnesota Department of Natural Resources	Long-Term Ecological Monitoring Network
Minnesota Pollution Control Agency	Intensive Watershed Monitoring Program
Minnesota Pollution Control Agency	National Lakes Assessment
University of Minnesota--Duluth	National Forest Bird Monitoring Project (NFB)
Smithsonian Conservation Biology Institute (SCBI) - Migratory Bird Center	Range-wide migratory connectivity & timing of annual events of the elusive Connecticut Warbler
The Nature Conservancy	Conifer Strongholds
The Nature Conservancy	Adaptation Forestry in MN Northwoods
University of Minnesota—Twin Cities	Carbon and nitrogen cycling under ecto- and arbuscular mycorrhizal tree species in a boreal forest system
University of Minnesota—Twin Cities	Environmental and genetic passportization of cloudberry on the southern borders of the European and North American area

Table 5.8-4 classifies the forty-six non-wilderness permits issued into the subject areas. Note some permits fall under more than one category:

Table 5.8-4. BWCAW research permits by subject area

Subject Area	Number of Permits
Soil, Air and Water Resources	8
Fire	3
Wildlife and Fish	15
Plant Community	11
Social	1
Geology	7
Climate Change	6

Every research subject area identified by the Forest interdisciplinary team had at least one permit associated with it. Though not identified by the team, the subject of geology had multiple permits issued between 2015 and 2017.

Implications

While the Forest issued many research permits between 2015 and 2017 that addressed our research subject areas of concern, the research conducted did not necessarily answer the management questions identified in the Forest Plan or by the Forest interdisciplinary team. This is because outside researchers apply for a permit to answer their own research questions and fulfill their own grant or funding needs. There is little awareness of the SNF's identified research needs outside of the Forest. In addition, it is hard to tell from the research project title and permit application whether or not the findings of the study will actually answer our management questions. Often times we must wait until results are published in a peer-reviewed journal—a process that can take years. Further, researchers within the Research branch of the Forest Service do not have to apply for a research permit on the SNF because they are employees. Therefore, any Agency conducted research is not the above tables.

Recommendations

As Forest Service researchers do not apply for their research permits, the identified indicators may not be the most appropriate way to answer this monitoring question. Additionally, there is little awareness of the SNF's research needs within the broader research community and there is no formal process established on the SNF for revising and updating the research questions listed here.

The SNF needs a process to communicate its research needs to the broader research community and to other Forest Service researchers. This would increase the likelihood that research conducted on the SNF answers identified management questions. Additionally, establishing an internal process for SNF staff to continually edit and update their list of research questions would ensure the agency is communicating our most up-to-date research needs.

5.9 Soil

Since the 2004 Superior National Forest Resource Management Plan (Forest Plan) became effective, soil monitoring has occurred from 2005 to 2009, along with corresponding monitoring reports. The 2012 Planning Rule changed the monitoring requirements from the 1982 Rule. With this, the Forest Service modified the regional soil monitoring standards and guidelines in 2012 as well. The new guidelines consider the range of natural variability and the ecological context of the soil. It also allows for adaptive management based on a forest's soil, since the conditions and ecological and physical context can be unique to that forest or region, for example the Great Lakes region.

Soil monitoring activities on the Superior National Forest - 2010-2017 include:

- Forest soil disturbance monitoring protocol on timber harvest sites.
- Minnesota DNR and Forest Resource Council timber harvest monitoring.
- Prescribed fire and wildfire monitoring.
- Mechanical scarification monitoring.
- Biomass utilization monitoring.
- Road decommissioning effectiveness monitoring.

5.9.1 Effects on Productivity of the Land Monitoring Question

Are the effects of Forest management, including prescriptions, resulting in significant changes to the productivity of the land?

The Superior conducts soil monitoring in areas having vegetation management completed under Forest Plan direction and NEPA-approved, which provide the design features for project implementation. The 2010-2017 reporting period addressed the monitoring question.

Last Updated

The last time a report was published was in 2009. Prior to 2010, the Superior utilized a different system of timber harvest soil monitoring. The value of the current system is using the nationwide protocol compared to every national forest using their own monitoring protocol.

Monitoring Indicator(s)

- Proportion of monitored sites detrimentally disturbed (rutted, compacted, eroded, displaced, burned, etc.) resulting from management activity.

Monitoring Frequency

For timber harvests, the monitoring frequency is usually on an annual basis. For other monitoring activities related to soil, the frequency has been variable.

Background & Drivers

- 36 CFR 219.12 (a)(5). The status of select watershed conditions; the effects of each management system to determine that they do not substantially and permanently impair the productivity of the land; 16 U.S.C. 1604(g)(3)(C).

- 36 CFR 219.12 (k) [2]. Documentation of the measured prescriptions and effects, including significant changes in productivity of the land; D-WS-3, D-WS-12, O-WS-9, O-WS-10.

The Forest developed this monitoring question to determine if soil guidelines are followed during implementation of projects, and to assess how effective those guidelines are in protecting the soil resource.

There are two units of measure for soil protection. The first is percentage of treatment area in a detrimentally compacted, eroded, rutted, displaced, or severely burned condition (G-WS-9). Forest floor (surface organic matter) lost resulting from a management activity (G-WS-11) is the second. These units of measure are effective and appropriate because they relate directly to Forest Plan guidelines designed to protect the soil resource. This information measure determines whether the project is following the guidelines and their effectiveness. Monitoring results can also determine how well the project followed G-WS-8 during management activity to determine if ecological land types (ELTs) consideration occurred.

In addition to units of measure, units of comparison are a component of soil monitoring. Pre-treatment condition is the unit of comparison for soil protection. The Superior conducts monitoring before management activities, such as harvest or prescribed burning, to establish baseline data and make comparisons with post-treatment conditions. The Forest also notes any pre-existing conditions during this phase of monitoring.

Timber Harvest Monitoring

The Forest uses a national protocol, the Forest Soil Disturbance Monitoring Protocol (FSDMP) (Gen. Tech. Report WO-82b, September 2009), for monitoring. This protocol helps quickly assess changes to some soil properties by evaluating:

- Forest floor impacted
- Live plant
- Fine woody (greater than 7cm)
- Coarse woody (greater than 7cm)
- Bare soil
- Rock
- Topsoil displacement
- Erosion
- Rutting (greater than 5cm, 5-10cm, greater than 10cm)
- Burning (light, moderate, severe)
- Compaction (0-10 cm, 10-30cm, 10-30cm)
- Platy/massive/puddled structure (0-10cm, 10-30cm, or greater than 30cm)
- Invasive earthworms

The monitoring protocol requires a minimum of 30 points per sampling unit. However, the form calculates the points needed per site based on the variability of the collected data and the

confidence interval and interval width established prior to sampling (Page-Dumroese et. al 2009b). Each monitoring point was assigned a disturbance class based on the greatest degree of disturbance in any parameter ranging from class 0 (no evidence of disturbance) to class 3 (severe disturbance). Although areas classified as class 3 are the most disturbed, they may or may not be detrimentally disturbed for some ecological systems. The evaluator used professional judgment to decide the level of detrimental impaction of each sampling location. The soils report in the project file contains additional details on the methodology, sampling design, and results.

Monitoring performed on pre- and post-timber harvests from 2010 - 2017 followed protocol using the FSDMP. In addition, informal monitoring occurred throughout implementation of the projects. Timber sale administrators ensure project-specific design criteria are included in timber sale contracts and that the purchaser follows the criteria.

Results

The FSDMP suggests conducting both a pre-harvest and post-harvest monitoring on the same site to determine the disturbance source. It should be noted the transect points are not the same points that are used for the post-harvest.

The following graphs in figures 5.9-1 and 5.9-2 demonstrate the amount of pre- and post-harvest soil disturbance found using the FSDMP. The point represents the average percentage of transect points that fell within a particular disturbance class. The line height represents the range of variability for each class. Transect points were used across all sites and classes to determine the average and range for each disturbance class.

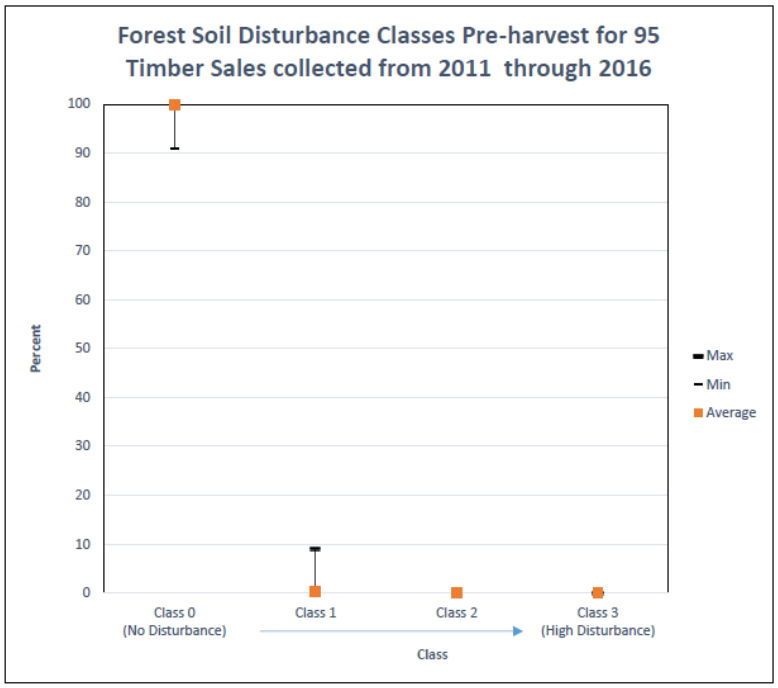


Figure 5.9-1. Forest soil disturbance classes pre-harvest, 2011-2016

Table 5.9-1. Pre-harvest monitoring percentage across all sites for each class

	Class 0	Class 1	Class 2	Class 3
Maximum	100	9	0	0
Minimum	91	0	0	0
Average	100	0	0	0

Out of the 95 sites sampled, class 0 dominated with 96 percent of all stands with a small amount (four percent of stands sampled) in class 1; with no recording of disturbance in class 2 or 3. Some soil compaction and puddling was evident in the 0 to 10 cm layer. Forest staff found worms at many of the sites, which typically leads to a decrease in the forest floor depth. The forest floor depth ranged from three to 12 cm and averaged six cm in depth.

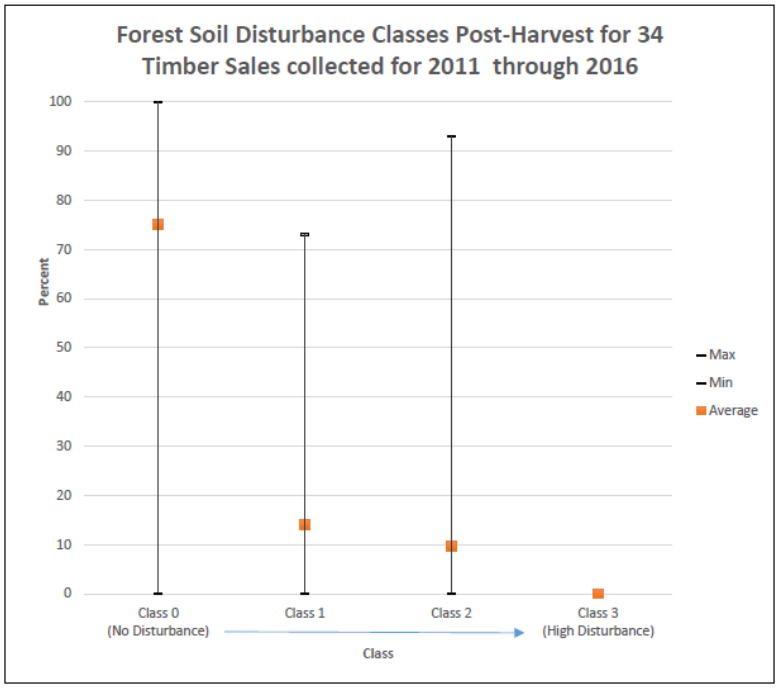


Figure 5.9-2. Forest soil disturbance post-harvest, 2011-2016

Table 5.9-2. Post-harvest monitoring percentage across all sites for each class

	Class 0	Class 1	Class 2	Class 3
Maximum	100	73	93	0
Minimum	0	0	0	0
Average	75	13	10	0

The level of soil disturbance increased overall as compared to the pre-harvest data. Only 61 sites out of the 95 were not included in the post-harvest data due to harvesting. Out of the 34 sites

sampled**,** soil disturbance class 0 dominated the landscape (75 percent of all stands sampled); while there was an increase in both class 1 and 2, 13 percent and 10 percent respectively. Rutting compaction, topsoil displacement, and puddling increased for all units sampled. Overall, rutting in the top five cm, compaction within the top 10 cm and puddling within the top 30 cm were the highest on average for all the parameters sampled.

Less than one percent of the post-harvest points were determined to be detrimental. Therefore, it was not included in the graph or table. However, with a transect method there are small areas of high disturbance, such as rutting, that are missed. The Superior will continue to record these impacted areas in the comment field.

Discussion

Specific data regarding changes from pre-harvest to post-harvest data collected from 2010 to 2016:

- As you can see from the graph and table on pre-harvest monitoring, there has mostly been little disturbance.
- Post-harvest monitoring shows a decrease in the class 0 level of disturbance and an increase in the percentage of stands in classes 1 and 2.
- Most increase in disturbance attributes to an increase in rutting within 5 cm of the soil surface, compaction within 10 cm of the soil surface, and puddling within 30 cm of the soil surface. Soil displacement occurred on some sites.
- From pre- to post-harvest, on average, the forest floor lost about one cm. Since non-native earthworms are present on a number of sites, it is difficult to determine if the loss of forest floor is due to timber management or an increase in earthworm activity.

This FSDMP monitoring shows an increase in disturbance from pre-harvest to post-harvest levels. It was determined those disturbances did not reach a level considered detrimental to soil productivity. Therefore, this implementation monitoring shows that the Forest is consistent with the 2004 Forest Plan.

Regional soil quality standards (USDA Forest Service, 2012 FSM 2550) call for consideration of ecological response to soil property changes as measured by reference conditions. Since 2010, less than one percent of the monitored points were detrimentally impacted; therefore, most of the area would be expected to return to the same level of ecological function as observed in adjacent undisturbed reference locations.

The monitoring also recorded informal observations of soil disturbance from timber harvesting. For example, while sampling effectiveness of biomass harvesting, nine of the fifteen sampled units contained rutting in wet inclusions. One unit had soil erosion on a skid trail.

NOTE: Erosion at the sites sampled was not an issue as there were no occurrences in the transect points recorded. However, if observed on the site, it could be recorded in the comment field.

Biomass

Occasionally, a timber harvest purchaser will request removal of biomass (timber slash) remaining on a site that can made into woodchips and sold. After the timber harvest, the operator removes the biomass and the payment unit is monitored to see how much slash is

remaining. There has been research regarding how much slash removal can occur without causing adverse effects to long-term soil productivity. (Grigal 2004). There are guidelines in the 2004 Forest Plan (SNF Forest Plan, 2004) and the Minnesota Forest Resource Council (MFRC) (MFRC Guidelines, 2102) has guidelines concerning the removal of slash.

Results

In 2013, monitoring occurred on two payment units after biomass harvesting took place. In 2016, monitoring occurred on thirteen payment units for biomass that was remaining. In all sites, the amount of biomass remaining was determined to be sufficient. There were a variety of sizes of wood (branches, boles etc.) and the remaining slash was not always evenly distributed. The following figure 5.9-3 shows an example of a variety of sizes of slash from fine to coarse-woody material remaining on site.

Figure 5.9-3. Post-biomass utilization site on the Little P Sale of the Kawishiwi District

Discussion

It was determined on all sites that there were biomass of various sizes remaining. However, at times it was unevenly distributed. It is preferred that the slash be evenly distributed. However, to spread the slash evenly, equipment would have to travel across the ground and it could cause more impact to the soil. The sampling method is subjective; in the future, the Forest could use a more scientific process. However, currently dispersal occurs on a limited basis depending on equipment costs, and a limited number of companies purchase biomass for utilizing the remaining wood after harvest. Other slash measurement techniques could exist, which would fit with the MFRC Guidelines.

Mechanical Scarification Monitoring

A few sites have had monitoring but not on an annual basis. The type of monitoring has been observational in nature.

Discussion

Importantly, the Forest used a different monitoring method. For example, mechanical scarification monitoring utilized visual observations, while FSDMP used a transect method.

The nature of mechanical scarification is to cause more disturbance to the soil to achieve silvicultural objectives; thus, some detrimental disturbance may occur. For example, mechanical scarification reduces competition for paper birch seeds or for planting conifer seedlings. While erosion and rutting are typically minimal, the removal of organic matter is the type of soil disturbance that can cause detrimental impacts. The important thing is to limit the amount of detrimental disturbance while still achieving silvicultural objectives. Another consideration is the soil type and the ecological context.

Prescribed fire and Wildfire Monitoring

- In 2015, Forest staff monitored a prescribed fire near Slim for organic matter remaining after the burn.
- In 2015, Forest staff monitored a prescribed burn near Burntside Lake for organic matter remaining after the burn.
- In the fall of 2011, Forest staff monitored the Pagami Creek Fire near Lake Isabella as part of a burned area emergency rehabilitation (BAER) assessment, with a follow-up in the spring of 2012.
- In 2016, Forest staff monitored two wildfires as part of a BAER assessment – Foss Lake and Skibo.
- From 2012 to 2016, Forest staff monitored oak-blueberry prescribed burns for effectiveness in ecologically restoring the site and the amount of organic matter remaining. These sites occurred on shallow to bedrock soils (ELT 18).

Results

The prescribed fires had some remaining litter layer remaining. However, the prescribed burn at Burntside Lake had some inclusions where the fire had burned off the forest floor. The two small wildfires, Skibo and Foss Lake, had the litter layer remaining with inclusions of severe burning. However, in most cases with the Pagami Creek Fire, the soil forest floor was mostly to entirely burned, with the burn severity being primarily moderate and severe.

Figure 5.9-4. Pagami Creek fire hillslope-overlooking a swamp in the spring of 2012 (south of Isabella Lake, SNF)

Discussion

Based on the amount of litter layer remaining after a burn, the Pagami Creek Fire, a wildfire, has had the most impact to the soil resource. There was also evidence of soil erosion, although that has subsided due to the regrowth of the vegetation. However, the soil erosion would have been greater if it was not for the complexity of the rocky landscape. Fire lines, especially those created by a bulldozer, can have big impact on the soil resource by removing the organic layer. For the Pagami Creek Fire, the Forest used dozers outside of the BWCAW. After the fire, backhoes pulled back vegetation onto the fire line. In 2014, Forest staff monitored the fire lines in areas where the dozers went through black spruce swamps (ELT 6). In the monitored areas, there was good diversity of tree seedlings, forbs, and shrubs.

Road decommissioning effectiveness monitoring

In 2013, the Superior monitored eight roads for decommissioning effectiveness on the west zone. Typically, the first 150 feet from a traveled road would have a series of berms, boulders, trees planted, soil scouring, and root wads from tree stumps.

Results

With two exceptions, which had limited all-terrain vehicle (ATV) use, road decommissioning was very effective and Forest staff did not observe other vehicle use on the roads. Mostly, the roads were essentially impassable, and even difficult to walk.

Discussion

Overall, the road decommissioning was effective in keeping ATVs and other vehicles from traveling further down the road. Typically, the adjacent vegetation was growing in towards the road, so over time it was barely noticeable that road was there. In areas where the surrounding vegetation is more open, ATVs would have an easier time going around the road.

Statewide Best Management Practices Monitoring

During the 2010 – 2017 period, the MN DNR and MFRC conducted statewide timber harvest and forest management guideline monitoring. The monitoring program published reports for 2011(statewide report), 2014-2015 (watershed report; included two major Superior National Forest watersheds), and 2016-2017 (watersheds report, included one minor Superior National Forest watershed) (Rossman 2012, Rossman 2016, Rossman et al. 2016 and Rossman et al. 2018). The monitoring program tracks the implementation of best management practices across county, State; federal and private ownerships to determine implementation of recommended BMP guidelines according to the handbook - Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers (MN DNR 2012).

Discussion

The three reports listed above include parts of the Superior National Forest. The following is a summary of general trends found across all management ownerships, types, and landforms.

1. Reduction in infrastructure size. Problem areas include increased landing and infrastructure size on harvest areas greater than 30 acres. MFRC guidelines suggest no more than three percent of the timber harvest in infrastructure. However, if less than 30 acres, use no more than five percent. Mostly used existing infrastructure.
2. Increase in compliance with sites meeting biomass retention guidelines. Non-biomass utilization sites meeting or exceeding slash retention guidelines increased.
3. Fewer approaches and segments need erosion control installed, most likely because of site selection. However, segments and approaches needing erosion control and having it installed has decreased and then leveled off. If a site needed but did not have erosion control measures in place, soil erosion was most likely to occur at those sites.
4. Rutting has decreased both across the general harvest area and at non-open water wetland crossings. The percent of avoidable waterbody crossings has increased.

In 2016, Rossman wrote a report focusing on the SNF sites monitored for BMP compliance in 2014 and 2015. He states that BMP compliance rates on SNF lands was generally high. However, avoidance of wetland crossings could use improvement.

Recommendations

Mostly, compliance with guidelines occurred. However, there could be improvement. See below for some general recommendations.

1.) Increase compliance with infrastructure guidelines:

   a.) Minimize the size of landings.

   b.) Locate landings away from wetlands and filter strips.

   c.) Reduce infrastructure when harvest areas exceed 30 acres or more in size.

2.) Retain fine woody debris on biomass harvest sites.

3.) Avoid wetland and waterbody crossings when an upland route is available.

4.) Increase the use of erosion control via water diversion or erosion control structures (slash water bars or scattered slash).

5.) Keep soil surfaces covered with vegetation.

6.) Use erosion control near stream crossings with trout streams (Lake Superior North and South, roughly east zone on Superior National forest).

Soil monitoring can help develop management practices that maintain soil productivity on the SNF by analyzing the FSDMP data and comparing them to various treatments. The goal is to understand soil productivity qualities relating to long-term sustainability, site resilience, and hydrologic function. Moving forward, the SNF should continue to utilize the FSDMP to monitor land management activities to ensure that the soil on the SNF remain productive. It is important to evaluate the effectiveness of FSDMP and make changes as needed. For example, in 2018, changes to the sampling scheme helped to better represent the harvest area.

Monitoring results show that design criteria improvement would better protect the soil resource and reduce the overall extent of soil disturbance on managed lands. Such adjustments should consider observed changes in seasonal trends (summers have been wet and less winter frozen conditions), along with changes in design criteria language regarding operating seasons and their associated requirements.

Some specific recommendations include:

- Analyze the need for which soil types have more disturbance on them. In the past, the goal was to conduct timber harvest monitoring on a variety of different soil types. The results of that analysis may lead to more monitoring on specific soil types.
- Continue the monitoring from 1997, 1999, 2003, and 2018 on landings, temporary roads, and skid trails for measurements relative to the overall harvest unit. This monitoring will continue in 2019.
- Continue monitoring on ELT 18, zero to eight inches of soil over bedrock. What are the ecological implications of not managing that soil type?
- Analyze the results of ELTs, season of harvest, harvest types, and coarse fragment percentage in future reports with the FSDMP.
- Review the protocol to ensure the sampling protocol is representative of the site conditions. Consider adjustments to the FSDMP (more sample points, mapping infrastructure) if a number of detrimental disturbed areas are not being sampled. However, more time monitoring one site may lead to less site monitoring overall.
- Monitor more fires, both prescribed burns and wildfires, during different soil moisture conditions and seasons. If possible, monitor the depth of the forest floor before a prescribed burn. Consider using the FSDMP.
- Prevent catastrophic wildfires, such as the Pagami Creek Wildfire, to limit the severe burning of the forest floor.
- Monitor more mechanically scarified sites, preferably on an annual basis. Consider using the FSDMP.

References

Grigal, D.F. 2004. An Update of Forest soils. A Technical Paper for a Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota. Prepared for Laurentian Energy Agency, 2004.

Page-Dumroese, Deborah, Ann Abbott, Tom Rice. 2009. Forest Soil Disturbance Monitoring Protocol, Volume I: Rapid Assessment. United States Department of Agriculture, Forest Service. General Technical Report WO-82a.

Page-Dumroese, Deborah, Ann Abbott, Tom Rice. 2009b. Forest Soil Disturbance Monitoring Protocol, Volume II: Supplementary Methods, Statistics, and Data Collection. United States Department of Agriculture, Forest Service. General Technical Report WO-82b.

Rossman, R., 2016. Implementation of Timber Harvesting and Forest Management Guidelines on Superior National Forest Land within Superior North & South, Vermillion River and Rainy River Headwaters Watersheds. 2014 and 2015 Monitoring Summary. MN DNR Division of Forestry.

Rossman, R., 2012. Timber harvesting and Forest Management Guidelines on Public and Private Forest land in Minnesota Monitoring for Implementation 2011. State of Minnesota, Department of Natural Resources. http://mn.gov/frc/docs/MNDNR_FMG_monitoring_2011_report.pdf Rossman, R., J. Corcoran and R. Slesak, 2016. Timber Harvesting and Forest Management Guideline Implementation on Public and Private Forest Land in Various Watersheds in Minnesota Monitoring for Implementation 2014 & 2015. State of Minnesota, Department of Natural Resources. http://mn.gov/frc/docs/Site-level_monitoring_2014-2015_Monitoring_Report_Final.pdf

Rossman, R., J. Corcoran and R. Slesak, 2018. Timber Harvesting and Forest Management Guideline Implementation on Public and Private Forest Land in Forested Watersheds in Minnesota Monitoring for Implementation 2016 & 2017. State of Minnesota, Department of Natural Resources. http://mn.gov/frc/docs/Site-level_2016_2017_%20Guidleine-Monitoring-Report_updated.pdf

Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers (Revised 2012): MN DNR 2012. https://mn.gov/frc/docs/MFRC_Revised_Forest_Management_Guidelines_(2012).pdf

USDA Forest Service. (January 31, 2012). FSM 2500 Watershed and Air Management, Chapter 2550 Soil Management.

5.10 Timber

Key points of note for timber management from fiscal years 2014 through 2017 are:

- Treated 19,947 acres, or about 15 percent of the projected acres treated as envisioned in the Forest Plan.
- Harvested on about two percent of lands suitable for harvest.
- Varied harvest methods including thinning on 10 percent, clearcutting on 68 percent, shelterwood and partial cut on 16 percent, and uneven-age treatment on six percent.
- Certified restocking of 12,490 acres.

5.10.1 Projected Outputs and Services Monitoring Question

How close are projected outputs and services to actual?

Results

Table 5.10-1 shows that during this monitoring period, outputs for acres treated through harvest have been below projected outputs in Forest Plan Appendix D-Proposed and Probable Practices, Goods Produced and Other Information.

Table 5.10-1. Harvest acres treated 2014-2017

Fiscal Year	Forest Plan Projection*	Actual Harvest Acres Treated	Percent (%) of Projection
2014	13,241	3,537	26
2015	13,241	6,191	46
2016	13,241	5,411	40
2017	13,241	4,808	36

*Forest Plan projections are based on decade 2 harvest projections evenly proportioned by fiscal year.

Discussion

Table 5.10-1 displays actual treatment acreage on the Forest. Harvest can vary greatly on a year-by-year basis depending on multiple conditions. Although the treatment acres vary, the overall trend points to a lower than desired amount of acres treated through harvest to achieve Forest Plan vegetation management objectives. Forest Plan desired conditions and objectives include a wide range of resources including landscape ecosystems; vegetation composition and structure, spatial patterns, and ecological processes; wildlife habitat, and insect, disease and disturbance processes.

5.10.2 Harvested Lands Restocked Monitoring Question

Is the Forest restocking harvested lands adequately r after five years?

Results

During fiscal year (FY) 2010-2012, most of the regeneration harvest activities were stand clear-cuts and coppice cuts. About 87 percent of these were certified stands. Approximately 13 percent of the stands show some error with the database.

Discussion

Forest staff conduct stocking surveys at the third and fifth-year post harvest. For this question, this discussion presents stocking levels from harvest that have occurred between FY2010 – FY2017. Stocking surveys conducted then show that restocking occurred on surveyed upland stands within a five-year period from harvest and lowland stands were adequately stock in an 8-10 year period. During this timeframe, the Forest certified 12,490 acres and met the National Forest Management Act requirements.

5.10.3 Extent of Timber Management on Suitable Lands Monitoring Question

To what extent is timber management occurring on lands suitable for such production?

Results

Timber management has occurred on roughly two percent of lands suitable for timber production from 2014 through 2017. Within the suitable land base of about 921,000 acres, harvest occurred on about 19,947 acres.

Discussion

Forest Plan objectives project that harvest would occur on approximately 14 percent of the suitable land base during the second decade. During the monitoring period, which represents about 40 percent of the second decade, harvest has occurred on roughly two percent of the suitable land base. A portion of this harvest activities were from timber sales that sold during the previous monitoring period and harvested during this period. Acres sold during this monitoring period total 18,641 and should be harvested during Forest Plan decade 2. Suitable land base shown in the 2004 Forest Plan is 944,908 acres of land suitable for timber production. As of 2017, a query of the suitable land base show a decrease in acres of 23,886, totaling 921,022.

5.10.4 Amount of Even-aged Management Monitoring Question

How much even-aged management (especially clear cutting) is being used, and in what forest type?

Results

Table 5.10-2 estimates acres of harvest by treatment method from FY2014-FY2017. The Forest Plan percentages shown in table 5.10-2 are from the Forest Plan Appendix D, Table APP-D2.

Table 5.10-2. Estimated acres of timber harvest by treatment method forest wide for decade 2 (FY2014-2017)

Treatment Method	Acres	Percentage (%)	Forest Plan (%)
Thinning	3,224	16	10
Clearcutting	15,223	76	68
Shelterwood & partial cut	1,404	7	16
Uneven-aged	96	0	6
Totals	19,947	99	100

Discussion

The Forest Plan estimates for second decade probable treatments to show treatment types for thinning, clearcutting, shelterwood, partial cut, and uneven-age management. Table 5.10-2 displays the actual harvest method for the monitoring period and the projected Forest Plan objective for the second decade. The actual percentage show a snapshot of where the Superior is running at about 40 percent of Plan implementation. It also demonstrates that the Superior is slightly above the projections for thinning and clearcutting but behind for shelterwood, partial cut, and uneven-age management treatments. A portion of these harvest percentages have come from timber sales sold prior to the current monitoring period; however, timber sales sold during this period vary around less than one percent of the reported harvest acres.

Recommendations

Timber management treatments can address many Forest Plan vegetation management desired conditions and objectives. Sections 5.13-Vegetation and 5.15-Wildlife of this report address vegetative conditions relative to Forest Plan objectives. As shown in the discussion for the Extent of Timber Management on Suitable Lands Monitoring question, treatment acres are well below the expected amount to implement the Forest Plan and accomplish objectives. Increased use of timber harvest treatments can achieve objectives for landscape ecosystems; vegetation composition and structure, spatial patterns, and ecological processes; wildlife habitat, and insect, disease and disturbance processes. Forest landscape restoration can result from treatments to address forest stands with reduced growth, development, and vitality.

5.11 Transportation

The road inventories and management decisions subsection describes the change in National Forest System (NFS) road mileage status between 2009 and 2015. The road closures and decommissioning subsection includes a discussion of road miles closed or decommissioned during fiscal year (FY) 11 through FY17, along with field monitoring summaries disclosing the effectiveness of the closures in meeting resource objectives.

Roads are categorized as wholly or partly within or adjacent to and serving the Superior National Forest (SNF) and are necessary for the protection, administration, and utilization of the NFS and the use and development of its resources (36 CFR 212.1). Unauthorized roads (previously known as unclassified roads) are those roads that are not a NFS road, trail, or a temporary road, and are not included (36 CRF 212.1). Temporary roads are roads necessary for emergency operations or authorized by contract, permit, lease, or other written authorization that are not a NFS road or trail, and that are not included (36 CFR_212.1).

5.11.1 Providing Necessary Road Systems Monitoring Question:

To what extent is the Forest, in coordination with other public road agencies, providing safe, cost effective, minimum necessary road systems for administrative and public use?

The Forest monitored this question by measuring the following indicators:

- Miles of road maintained by maintenance level (1 thru 5).
  Taking action to keep the miles of road maintained constant or declining will address the minimum necessary road system requirement.
- Amount of funding spent on road maintenance.
  Comparing the amount of funding over time per mile of road will address the cost effective requirement, though it will not reflect the quality of the maintenance or the condition of the road.
- Amount of funding obtained for specific projects.
  - Specific project funding is necessary to fund larger road projects through the base funding levels, such as bridge replacements and long segments of road reconstruction.
- Number of county and State projects supported by the Forest.
  - This indicator will address the coordination aspect of the monitoring, which is important for the Forest to act in partnership with local agencies to maintain service continuity throughout the system.
- Miles of road decommissioned.
  Taking action to increase the miles of road decommissioned will address the minimum necessary road system requirement.

Results for Road Inventories and Management Decisions

Miles of road maintained

Table 5.11-1 shows the road mileage from 2009-2017 on NFS roads, as well as shows the planned mileage for the end of the first decade of the Forest Plan.

Table 5.11-1. Road mileage by classification from the infrastructure database (INFRA) on the Superior National Forest

Year	OML 1	OML 2	OML 3	OML 4 & 5	Total System Roads	Inventoried Unauthorized[1]	Total Roads[2]
2009	880	907	231	401	2,410	264[3]	2,674
2017	806	1,148	285	279	2,517	227	2,744

1. Data will be updated when TMR is implemented.
2. Reflects revised unauthorized roads.
3. Reflects additional roads discovered through enhanced project inventories and large vegetation project decisions to decommission or convert to NF System roads.

Funding

Funding for general road maintenance comes in the form of CMRD funds, or Forest Service engineering funds. In 2009, CMRD funds totaled $683,273 dollars. In 2017, the CMRD funds totaled $747,000 dollars. This was an increase of $63,727 dollars, or about nine percent. Funding for specific projects can take on a variety of forms, and comparison is difficult due to year-to-year variability. In 2015, the Forest received $500,000 dollars in special funding for reconstruction of a portion of FR 170.

Coordination with State/County Projects

Coordination on projects with the State and counties has typically been through the Federal Lands Access Program (FLAP). In 2014, the Superior NF supported two county projects for this funding source. The first was the reconstruction of St Louis County State Aid Highway 16, and the second was with Lake County for rehabilitation of the Garden Lake Bridge. In 2017, the Superior NF supported the St Louis County State Aid Highway 44 reconstruction via the FLAP program.

Analysis

Since 2009, the miles of OML 1 and 2 roads have increased by 167 miles, or approximately nine percent. This increase is likely due to corrections of errors in the database and accompanying roads GIS layers, as well as changing unclassified roads to OML 1 and OML 2 roads.

Between 2009 and 2017, the total miles of OML 3, 4, and 5 roads have decreased by 68 miles, or about 11 percent. This change relates to correcting errors in the database and fixing inaccurate mileages. This condition is consistent with Forest Plan objectives for building few, new OML 3, 4 or 5 roads and maintaining the system with the minimum roads needed to provide adequate access.

Unauthorized road mileage decreased from 264 miles in 2009 to 227 miles in 2017. A Forest Plan objective is close unauthorized roads. The Forest will strive to meet this objective by implementing Forest Plan direction either to add these roads to the system or to decommission them.

Results for Road Closures and Decommissioning

Miles of road decommissioned

Table 5.11-2 shows the road mileage decommissioned for system and non-system roads from 2009 through 2017. Since 2009, 105.6 miles of road decommissioning has occurred.

Table 5.11-2. Miles of road decommissioning from various databases from 2009-2017

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
System	0.6	0	2.1	0	0	0	0	9.9	0
Non-System	11.9	15	0	9.1	7.2	11.9	10.5	11.6	15.8
Total	12.5	15	2.1	9.1	7.2	11.9	10.5	21.5	15.8

Analysis

The Superior National Forest continues to decommission both system and non-system roads. Even though 105.6 miles of road have been decommissioned, the total catalogued road mileage on the Forest has increased by 70 miles. The main reason for the increase in mileage is not construction of additional roads, but rather designation of newly found unauthorized roads as National Forest System roads. We also anticipated that the actual decommissioned road mileage is higher than recorded as field investigations show that many unauthorized roads have since grown in naturally and are in essence decommissioned. Of the 227 miles of unauthorized roads noted in table 5.11-1, approximately 80 miles have been field verified as grown in but have not yet been entered into the database as 'decommissioned.' Nevertheless, the Forest continues to decommission roads to bring the system to the minimum necessary for administrative and public use (table 5.11-2).

Another reason for the minimum numbers of decommissioned roads is due to a need for system road availability for timber hauling. The Travel Management Ruling, Subpart A, resulted in very few roads categorized as "likely not needed", and the Superior National Forest anticipates that a reduction of system road miles will not occur until the requirement guidance for timber hauling changes.

Decommissioning success varies greatly. It depends mostly on two factors: the contractor's quality of work performing the decommissioning and the forest user's desire to continue using the decommissioned road.

Figure 5.11-1. Nira/Peeler old road prior to decommissioning (spring of 2007) (left) and two years later (fall of 2009) (right).

Monitoring following road decommissioning projects implemented in 2001 were determined as successful (see figures). The road corridor shown below was essentially not noticeable as it blended into the natural landscape after decommissioning.

Figure 5.11-2. Gunflint Salvage project area temporary road immediately after decommissioning (2001) (left) and eight years later (2009) (right).

Recommendations

Monitoring network road miles is a simple and effective way to get a snapshot view of the network changes relating to Forest Plan direction. Additionally, monitoring the miles of road decommissioned would help show the progress towards reducing unauthorized road mileage to zero.

While funding levels are an interesting data point, they fail to provide insight into the quality of the performed maintenance or the actual road system conditions relating to public and administrative travel. Monitoring the cost per mile of grading, brushing, and mowing, in addition to total funding, would provide better insight into how funding compares with real costs.

Finally, a pavement surface evaluating and rating system (PASER) started in FY 2016 inventories the surface condition of gravel-surfaced roads on the Federal Lands Transportation Program (FLTP) road network. The frequency of this survey is unknown at this point, but if

conducted on a regular basis, it could monitor and evaluate the actual road surface conditions directly.

Annually monitoring the miles of decommissioned road is an effective and essential way to ensure the Forest continues to maintain a minimum road system and eliminate unauthorized roads. It is necessary to update the databases to ensure they are reflecting the current road conditions. We recommend continuing to monitor this indicator.

5.12 Tribal Rights and Interests

The history of federal treaties, statutes, court decisions, policies, and Presidential directives regarding American Indians is complex and extensive. The relationship between the Superior National Forest and the Bois Forte, Fond du Lac, and Grand Portage Bands of Chippewa is unique and distinct from those that apply to other interests, and constituencies, and one based upon the principles of tribal sovereignty.

The Superior National Forest recognizes and affirms the unique character of the government's relationship to the Indian tribes. The lands within the National Forest System are affected by pre-existing rights, retained by treaty, and are vested with these federally recognized tribes. Grand Portage, Fond du Lac, and Bois Forte bands each actively pursue the exercise of their reserved rights on National Forest System lands and waters. The 1854 Treaty Authority for Bois Forte and Grand Portage, and the Great Lakes Fish and Wildlife Commission (GLIFWC) for Fond du Lac, have delegated tribal authority to assist in the sustainable management of natural resources both on and off reservation.

This section contains topics of functional government-to-government consultation, improved relationships with the tribes, and facilitating the tribal right to hunt, fish, and gather as retained via treaty.

5.12.1 Tribal Rights and Interests Monitoring Questions

There are three monitoring questions pertaining to tribal rights and interests:

Is Forest management helping to sustain American Indians' way of life, cultural integrity, social cohesion, and economic well-being?

Indicator: The issues discussed at meetings between the bands and the Forest.
Monitoring Driver(s) include the following Forest Plan desired conditions (D) and objectives (O) for tribal relations (TR), D-TR-1, O-TR-1, and O-TR-3.

- **D-TR-1:** Lands within the Forest serve to help sustain American Indians' way of life, cultural integrity, social cohesion, and economic well-being (p. 2-37).
- **O-TR-1:** Improve relationships with American Indian tribes in order to understand and incorporate tribal cultural resources, values, needs, interests, and expectations in forest management and develop and maintain cooperative partnerships projects where there are shared goal (p. 2-37).
- **O-TR-3:** Superior National Forest facilitates the exercise of the right to hunt, fish, and gather as retained by Ojibwe whose homelands were subject to treaty in 1854 and 1866 (10 Stat. 1109 and 14 Stat. 765). Ongoing opportunities for such use and constraints necessary for resource protection are determined in consultation with the following Ojibwe Bands: Fond du Lac, Grand Portage, and Bois Forte (p. 2-38).

1. Are government-to-government relationships functional?

Indicator: Percentage of large-scale vegetation projects that government-to-government consultation occurred pre-scoping and pre-NEPA.
Monitoring Drivers include the following Forest Plan desired conditions and objectives for tribal relations, D-TR-2, O-TR-2, and O-TR-4.

- **D-TR-2:** The Forest Service continues to work within the context of a respectful government-to-government relationship with tribes, especially in areas of treaty interest,

rights, traditional and cultural resources, and ecosystem integrity. The Forests provide opportunities for traditional American Indian land uses and resources (p. 2-37).

- **O-TR-2:** Maintain a consistent and mutually acceptable approach to government-to-government consultation that provides for effective tribal participation and facilitates the integration of tribal interests and concerns into the decision-making process (p. 2-38).
- **O-TR-4:** consult, as provided for by law, with tribes in order to address tribal issues of interest and national Forest management activities and site-specific proposals (p. 2-38). .

2. As retained via treaty, is the Forest facilitating tribal rights to hunt, fish, and gather.

Indicator: The issues discussed at meetings between the bands and the Forest.
Monitoring Driver includes the following Forest Plan desired condition for tribal relations:

- **D-TR-3:** Superior National Forest facilitates the exercise of the right to hunt, fish, and gather as retained by Ojibwe whose homelands were subject to treaty in 1854 and 1866 (10 Stat.1109 and 14 Stat. 765). Ongoing opportunities for such use and constraints necessary for resource protection are determined in consultation with the following Ojibwe Bands: Fond du Lac, Grand Portage, and Bois Forte (p. 2-37).

The intent of the monitoring questions and drivers is to ensure that the Superior National Forest is:

- Consulting with the tribes as independent governments and not as members of the public or interest groups.
- Implementing treaties and trust responsibilities.

Monitoring Methods:

From 2009 through 2017, SNF staff expanded efforts to consult with tribal chairs, staff, and the 1854 Treaty Authority.

The Forest conducted a review of Forest-wide projects and programs to ensure that government-to-government consultation occurred, with an emphasis on conversations prior to requesting input from the public. The Forest Service's correspondence database documents consultation, as does the National Environmental Policy Act (NEPA) and other project files, and in tribal consultation meeting minutes. The Forest reviewed the schedule of large-scale vegetation projects and made comparisons to draft and final project reports for documented consultation documents. In addition, the Forest reviewed consultation-meeting notes.

The Forest held meetings at all levels. These included with elected officials, tribal chairs and councilors, various tribal staff, the forest supervisor, district rangers, and district and headquarters staff. Meeting settings included working one-on-one and in small groups with band members and representatives as each entity to improve communication and coordination. The tribes received the Superior Quarterly publication, which provides a written report of activities that will occur each quarter. In addition, tribal consultation occurred for specific projects of interest, along with information on individual SNF projects.

To determine tribal involvement in large-scape NEPA projects, the Forest completed a review of all projects in the Superior National Forest website, https://www.fs.usda.gov/superior. The Forest also reviewed the Records of Decisions for each project. The link to the projects from 2010 through 2017 is

https://www.fs.usda.gov/wps/portal/fsinternet/cs/projects/superior/landmanagement/projects?archive=1&sortby=1 .

Results

A review of large-scale projects from 2010 through 2017 indicated that project consultation and government-to-government contacts occurred with Fond du Lac, Bois Forte, and Grand Portage Bands of Chippewa, and with 1854 Treaty Authority for all large-scale vegetation projects. Consultation occurred in several forms:

- Annual Forest consultation meetings included discussions between the Forest and each of the three bands regarding current and future (five years) planned veg projects.
- Letters sent to tribal chairs, typically prior to public scooping and when requested, with meeting invites.
- Input from the meetings and any band correspondence became part of the project records.

Figure 5.12-1. Superior National Forest Supervisor, Brenda Halter, and Fond du Lac Tribal Chairwoman, Karen Diver, shake hands after signing the Tribal Use of Campgrounds Memorandum of Understanding on August 19, 2013 at the Fond du Lac Reservation

One way the Forest addressed the monitoring questions that forest management is facilitating the right of the tribes to hunt, fish, and gather as retained via treaty and is helping to sustain American Indians' way of life was through the development of a Memorandum of Understanding (MOU). This documented was and signed by the chairs of each of the three Bands of Chippewa for tribal use of campgrounds. This MOU ensures access to Forest campgrounds for tribal members.

Implementation has occurred on the recommendations from the last SNF monitoring report for Tribal Affairs (2009). These included:

1. Develop a Superior National Forest Tribal Strategy to describe expectations and provide consistency across the Forest to help:
    - Government-to-government relationships be functional.

- Management work to sustain American Indians' way of life, cultural integrity, social cohesion, and economic well-being.
- The Forest facilitate the right of the tribes to hunt, fish, and gather as retained via treaty.

2. Include project notes from consultation in the large-scale vegetation project records that would include:
   - The effectiveness of the consultation for concerns raised.
   - The recommended mitigation measures for addressing concerns to determine if tribal cultural resources, values, needs, interests, concerns and expectations for forest management were incorporated into the decision-making process.
3. Strive for early input and consultation with the bands so the SNF can mitigate actions, propose projects, and develop solutions that meet both the tribes and the Forest's needs. Moreover, so the SNF can fully meet its obligations to provide band members with their treaty rights and interest to the lands managed by the Superior National Forest.
   - The SNF continued to progress in building better relationships and accomplishing government-to-government consultation with the bands, yet the opportunity exists for improvement. Increase effort to focus on these activities and moving forward in FP desired conditions, and objectives, particularly O-TR-1 and O-TR-2, which highlight consolation and strengthening the bond between the Bois Forte Band, Fond du Lac Band, Grand Portage Band, the 1854 Treaty Authority, Great Lakes Indian Fish and Wildlife Commission, and the SNF. Increase Forest-wide documentation of consultation highlight and communicate forest expectations.

Results:

In 2010 and 2011, the SNF developed the Superior National Forest Tribal Consultation Framework to provide guidance and clarity of process to our work with the bands of the 1854 Treaty Authority. The information in this Framework, along with the Eastern Region Framework (2010) and the updated 2015, Tribal Relations Strategic Framework for the Eastern Region, Northeastern Area State & Private Forestry, and Northern Research Station provide the tools to ensure the Superior is adequately addressing the three monitoring questions. These frameworks support forest staff as they work to ensure that our government-to-government relationships are functional. In addition, they ensure Forest management helps to sustain American Indians' way of life, cultural integrity, social cohesion, and economic well-being; and that the Forest facilitates the right of the tribes to hunt, fish, and gather as retained via treaty.

Furthermore, the frameworks guide program delivery and enhance consistent application of and adherence to the laws and policies governing our relationship with American Indian sovereign tribal nations. They reflects the principles of Executive Order 13175, USDA Departmental Regulation 1350-002, Forest Service Manual 1563, and the Report to the Secretary of Agriculture, USDA Policy and Procedures Review and Recommendations: Indian Sacred Sites (Report). These documents are foundational and guide staff to understand what all is involved with federal Indian trust responsibility.

The federal Indian trust responsibility is a legally enforceable fiduciary obligation, on the part of the United States, to protect tribal lands, assets, resources, and reserved rights, as well to carry

out federal law mandates with respect to American Indian tribes. This responsibility requires that the Federal Government consider the best interests of the tribes with collaboration and when taking actions that may affect them. The trust responsibility includes protection of the sovereignty of each tribal government. The Superior National Forest's trust responsibility is primarily towards three Bands of Chippewa: the Bois Forte Band of Chippewa, the Fond du Lac Band of Lake Superior Chippewa, and the Grand Portage Band of Lake Superior Chippewa. They have reserved rights to the Forest's natural resources as established in the 1854 Treaty.

The federal Indian trust doctrine arises from Indian treaties, Supreme Court decisions, statutes, executive orders, and the historical relations between the United States and Indian tribes. In a broad sense, the trust responsibility relates to the United States' unique legal and political relationship with Indian tribes. It derives from the Federal Government's consistent promise in the signed treaties to protect the safety and well-being of the tribes and tribal members in return for their willingness to give up their lands.

Large Scale Vegetation Projects

The Superior National Forest Tribal Consultation Framework delineates the consultation process for large-scale vegetation projects. The process starts with discussing a project concept with the Bands. The process moves towards data gathering, program and project design, NEPA (when applicable), to project initiation, evaluation, and monitoring. Consultation is a continuous cycle and involves meetings (face-to-face whenever possible), discussions, and information sharing occurring throughout the entire cycle.

Forest-level consultation meetings often include discussions on individual projects. For example, projects that are in the concept stage, or the data gathering stage, or those in close proximity to a specific reservation, are often first introduced at a Forest-level consultation meeting. At the district level, government-to-government consultation occurs between the district ranger (decision maker) and the highest tribal elected officials. Forest staff consult band members as early as possible in the development of projects, policies, plans, and actions. All major projects are included in the consultation process. The intent is to consult with the tribes prior to contacting the public during public scoping.

The Forest uses the following steps during all major proposed projects. There are times, such as when an outside entity presents the projects to the Forest, that there may not be enough time to complete all the steps prior to public involvement.

1. The first step in consultation is during the initial project planning stages with the Bands.
2. The second step is for the district ranger to explain the development of the project and invite participation with each of the three tribal chairs. The Forest provides this prior to any public involvement and pre-scoping to the bands.
3. After making contact, the next step is to discuss a plan of action in a government-to-government manner, and preferably face-to-face. For district projects, the district ranger connects with the tribal chairs. For Forest-wide projects, the forest supervisor ensures connection occurs with the Bands.
4. Depending on the interest of the band to a particular project, there may be no action beyond the introduction of the project, while for other projects the bands might want to meet in person, or send a letter with comments.

5. Once a well-documented administrative record of government-to-government consultation has begun on a specific project, continue to be address during project design and implementation. It is a continuous cycle, with face-to-face meetings, discussions, and information sharing occurring throughout the entire cycle.

Recommendations

Record of decisions (ROD) should include a separate section for tribal involvement. While a number of RODs do list tribal affairs separately in the Table of Contents, others list it under Public. Our relationship with tribes is government–to-government and should not be treated as public engagement. The RODs and supporting documents should still include consultation effectiveness for raised concerns, and added mitigation measures to address the concerns to determine if tribal cultural resources, values, needs, interests, concerns and expectations for forest management were incorporated into the decision-making process.

Forest leadership should continue to strive for early input and consultation (pre-NEPA) with the Bands. With this, the SNF could mitigate actions, propose projects, and develop solutions that meet both the tribes and the Forest's needs, particularly so the SNF can fully meet its obligations to provide band members with their Treaty rights and interest to the lands managed by the Superior National Forest.

The SNF continues to make progress in building better relationships and accomplishing government-to-government consultation with the bands, yet the opportunity exists for improvement. An increased effort will be made to focus on these activities and moving forward in FP desired conditions, and objectives, particularly O-TR-1 and O-TR-2, which highlight consolation and strengthening the bond between the Bois Forte Band, Fond du Lac Band, Grand Portage Band, 1854 Treaty Authority, Great Lakes Indian Fish and Wildlife Commission, and the SNF. To assist in these efforts, the Forest will increase documentation of consulting, and highlight and communicate Forest expectations.

5.13 Vegetation

This chapter consists of five sections:

1. Landscape ecosystem objectives – described by vegetation composition and age class, tree species diversity, and management indicator habitats.

2. Vegetation spatial pattern objectives.

3. White pine (management indicator species and focal species).

4. Forest insect and disease.

5. Forest condition and restoration need – described by ecosystem sustainability; forest composition and structure; and ecological processes.

Sections (1) and (2) have been measured annually and documented in previous monitoring and evaluation reports. These sections provide an important evaluation to attain vegetation objectives across the Superior National Forest (Forest). Sections (3) and (4) have been measured, discussed, and reported on in both the vegetation and wildlife chapters previously. Section (5) is new to the report and provides information regarding forest condition and restoration need that may be useful as Forest moves towards an all-lands approach for forest management.

5.13.1 Landscape Ecosystem Objectives

Landscape ecosystems (LE) are ecological areas derived from a combination of individual or groupings of native plant communities, ecological systems, and terrestrial ecological units at landtype association and ecological landtype scales. Dominant vegetation communities and patterns characterize each LE. Monitoring LE objectives is important because these are Forest-wide objectives and one of the foundations of vegetation management direction in the Forest Plan. This report monitors and evaluates LE objectives in three ways:

1. Vegetation composition (forest type) and age class.
2. Tree species diversity.
3. Management indictor habitats (MIH).

The LE objectives compliment additional vegetation management direction found in the Forest Plan and apply to National Forest System lands only. The LE objectives set the direction for changes the national forest will strive to make within the short term (two decades) to move vegetation towards the long-term (100 years) desired condition. This information is also important for interdisciplinary teams as they plan, analyze, and implement vegetation management projects on the ground.

5.13.1.1 Landscape Ecosystem Monitoring Questions

The following questions are from the Forest Plan matrix in chapter 4:

1. To what extent is the Forest meeting vegetation composition and age class objectives for each landscape ecosystem?
2. To what extent are conditions moving toward short-term (1-20 years) and long-term (100-year) objectives at the landscape ecosystem, management areas, and other appropriate landscape scales?

Driver – **36CRF219.12 (a) (5) (ii)** The status of selected ecological conditions including key characteristics of terrestrial and aquatic habitats. This driver comes from the 2012 Planning Rule – Monitoring requirements.

Objective. O-VG-1. Move vegetation conditions from year 2003 conditions toward the long-term desired composition, age, spatial distribution, and within-stand diversity.

This driver comes from the Forest Plan and includes landscape ecosystem objectives for vegetation composition and age class; tree species diversity; and management habitat indicators (Forest Plan chapter 2). These monitoring questions and drivers are important for alignment with the 2012 Planning Rule – Monitoring requirements, and for staying on track with management of four important vegetation components. In addition, they help to move these components towards the long-term desired condition. Interdisciplinary teams use this information when determining the purpose and need for vegetation management activities; for conducting environmental planning and analysis; and for implementing vegetation management projects.

Indicators –

- Measured vegetation composition by the percent of acres of forest type, by LE.
- Measured age class by percent of acres of age class grouping by LE.
- Measured tree species diversity is the forest type change and number of seedlings planted by forest type.
- Measured management indicator habitats (MIHs) is the trend (direction of change) in the percent of MIHs in each LE for decades 1 and 2. The MIHs are a combination of forest types in three age categories (young, mature and old, old growth/ multi-aged) and are surrogates for ecological successional or vegetative growth stages. Appendix C of the Forest Plan contains detailed descriptions of the forest types and ages that comprise each MIH.

This report utilizes these indicators and units of measure because they provide a direct comparison with the Forest Plan objectives.

Method – Monitoring and evaluation is conducted for all six LEs found on the Forest: Jack pine/black spruce; Dry-mesic red and white pine; Mesic red and white pine; Mesic birch/aspen/spruce-fir; Sugar maple; Lowland conifers (including rich swamp). Monitoring and evaluation of vegetation composition, age class, and management indicator habitat objectives utilizes data extracted from the Superior National Forest FS VEG and FS VEG Spatial databases for 2014, 2017, and 2024, and compares them to decade 1 and decade 2 objectives in the Forest Plan. The Forest used the 2014 data to evaluate whether the Forest met objectives at the end of the first decade of plan implementation (2004 thru September 2013). The 2017 data are used to evaluate the current condition of the Forest; while the 2024 data are used to forecast where the Forest will be at the end of the second decade with current and proposed vegetation management projects (includes forest type and age changes due to succession and decisions (no proposals) as of the fall of 2017). Monitoring and evaluation of tree species diversity utilizes activity data (Forest Service Activity Tracking System) and stand-level forest types from the FS Veg Spatial database. The following figures (5.13-1 and 5.13-2) provide context for this evaluation of LE objectives and illustrates the relative amount of each LE Forest wide.

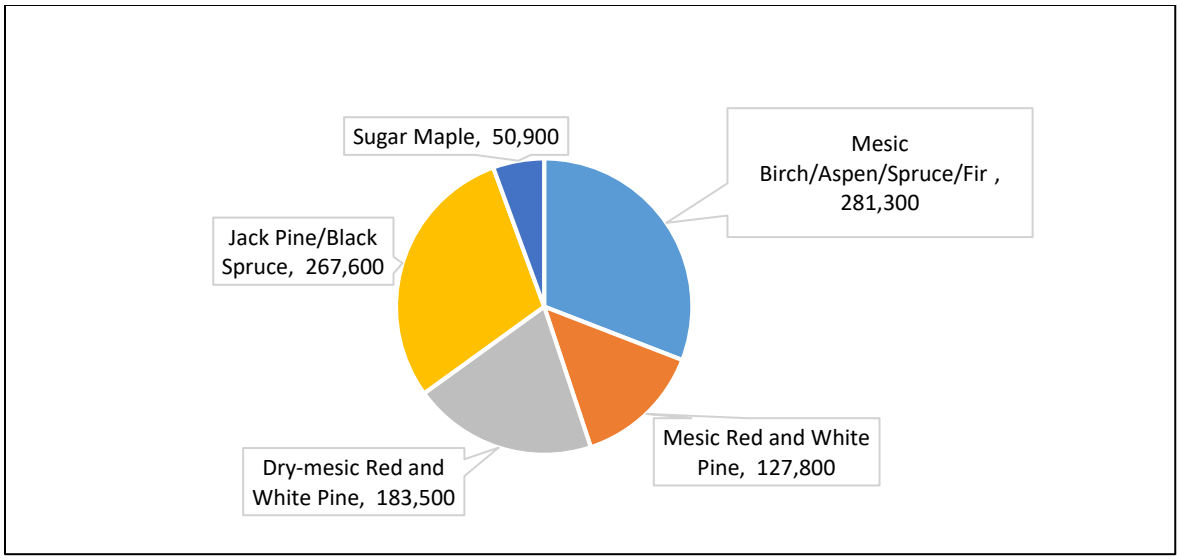


Figure 5.13-1. Superior National Forest upland LE acres

*Acres report in the 2004 Forest Plan

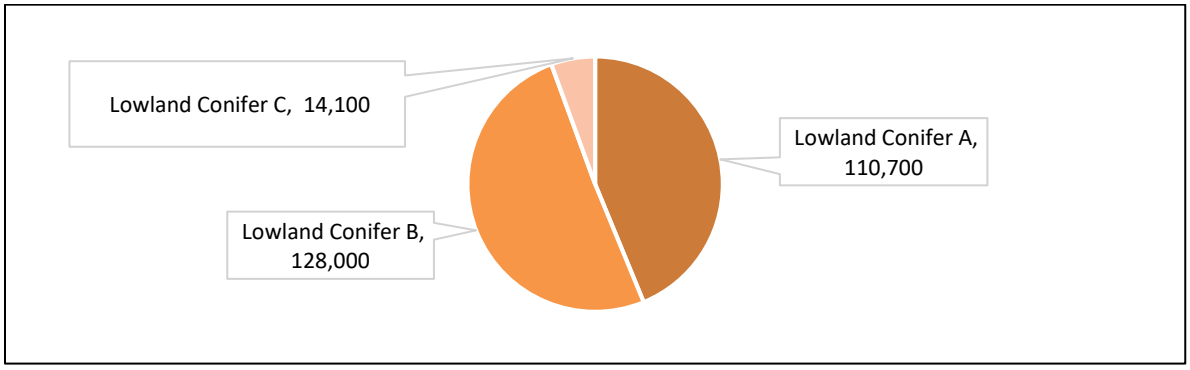


Figure 5.13-2. Superior National Forest Lowland LE acres.

*Acres report in the 2004 Forest Plan

Table 5.13-1. LE abbreviations for figure 2

LE Abbreviation	LE Type
DRW	Dry Mesic Red and White Pine
JPB	Jack Pine/Black Spruce
LLC	Lowland Conifer
LLC-A	Lowland conifer in JPB and DRW
LLC-B	Lowland conifer in MBA and MRW
LLC-C	Lowland conifer in SMA
MBA	Mesic Birch/Aspen Spruce/Fir
MRW	Mesic Red and White Pine

Results and Analysis – Age Class

- Attainment of first decade objectives 2004-2014 – Age Class
- Movement towards second decade and long-term objectives 2014-2024 – Age Class

Figures below display the measured changes in age classes from the beginning of the first decade (2004) to the end of the first decade (2014), as compared to Forest Plan objectives. Second decade projections are also included. Since Lowland Conifer and Sugar Maple LEs are much smaller than the other LEs, discussion here focuses primarily on the other LEs. Age class and composition tables for Lowland Conifer and Sugar Maple LEs are in the monitoring and evaluation report project file. Results are grouped by LE, however, some general trends were observed across the Forest:

By the end of the first decade, the percent of young upland forest (0-9 years) declined and older age classes increased in all LEs. The sapling to pole ages (10-50) increased. Young and sapling forest both showed trends in the desired direction but both fell short of Forest Plan objective amounts. In many LEs, nearly all of the mature and older age classes (50+ years) exceeded objectives. In upland LEs, Forest staff project mature and older age classes would continue to exceed objectives, while young forest continues to fall short of objectives by the end of the second decade.

How do these results relate to the projections for meeting Forest Plan decade 2 objectives, and what do they mean for the current state of the Forest? Because of the lower amounts of young forest created in the first decade, there will be an even steeper climb to meet decade 2 objectives for the 10-49 age class than there was in the first decade. It is also of interest to note that paper birch, quaking aspen, white and black spruce, tamarack, and balsam fir are tree species projected to decrease in abundance in northern Minnesota due to climate change (Handler *et al*. 2014). This means that in the future, it may be more challenging to recruit and regenerate these species on the landscape, adding to the difficulty in meeting young age class objectives. However, climate change studies project eastern white pine and sugar maple to increase in abundance, making it easier for managers to regenerate young age classes and expand acreage of these species on the forest.

Exceeding objectives in the older age classes could lead to poorer quality stands for timber sales. These stands could include too much decadent and dying aspen and birch, or increased fuel loads and risk of wildfire as older trees die and fall to the forest floor. This process increases the need and expense in using forest management tools other than standard timber harvest to restore these forest stands in the future.

Mesic Birch/Aspen Spruce/Fir (MBA) Landscape Ecosystem

Age class objectives for the MBA LE call for a decrease in young forest to 10 percent in decade 1 and 11 percent in decade 2 (0-9 age class—see table MBA-2 of Forest Plan). The first decade reduced the amount of young forest by almost half (from 13 percent down to six percent), resulting in not enough young forest in the LE (figure 5.13-3). By 2017, this number had decreased even further to four percent. In addition, older age classes (80-99 and 100+ years) recruited too much from younger age classes, exceeding decade 1 objectives of 21 percent and nine percent (figure5.13-3). By 2017, these numbers had continued to rise. Two of the middle age classes (10-49 and 50-79) also did not meet decade 1 objectives; however, 2017 data show they are trending in the right direction. At the current rate of management, the Forest calculates

that by 2024, the 0-9 age class to be about five percent in the MBA LE and not the 11 percent desired amount. In addition, the older age classes 80-99 and 100-plus may exceed Forest Plan objectives by five percent or more.

Because of the lower amounts of young forest created in the first decade, there will be an even steeper climb to meet decade 2 objectives for the 10-49 age class than there was in the first decade.

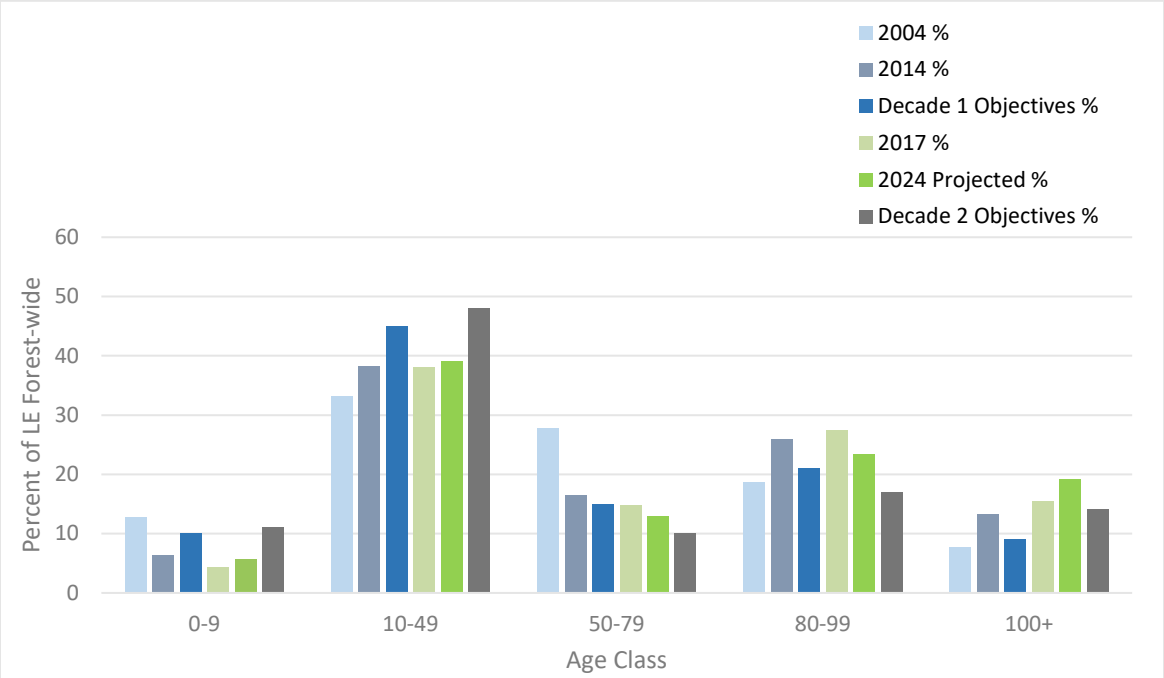


Figure 5.13-3. Mesic Birch/Aspen Spruce/Fir LE age class distribution

The MBA LE consists of short-lived, early successional species that regenerate best after stand-replacing disturbance. Fire suppression on the landscape has certainly played a role in shaping the current age class distribution. However, the amount of young forest may be a result of the management area direction in this LE discourages final harvest (FP table MBA-5).

Jack Pine/Black Spruce (JPB) Landscape Ecosystem

In the JPB LE, young age class (0-9 years) decreased over the first decade to 10 percent, but the objective was to increase to 14 percent (Forest Plan table JPB-2). By 2017, the acreage continued to remain low and continues to decrease in the 2024 projection falling short of decade 2 objectives (figure 5.13-4). In addition, one of the old age classes (110-179 years) surpassed its decade 1 objective with continued acreage increases by 2017 to 10 percent. By 2024, however, planned treatments should improve this imbalance.

Age classes 10-49 and 50-79 did not meet decade 1 objectives, but they trended in the right direction (increasing for 10-49, decreasing for 50-79). However, 2017 numbers show no growth in the 10-49 age class, with projections for 2024 to also remaining flat. Under these projections, decade 2 will continue to fall short in meeting the age class objectives. The 2017 numbers for age class 50-79 show that the Forest is maintaining acreage in the 10-49 age class above the desired objective and project to continue to exceed decade 2 objectives.

The 80-109 age class objectives call for a decrease in acreage to meet both decade 1 and decade 2 objectives. First decade and current 2017 data show little to no change in acreage in this age class, maintaining numbers above objectives for both decades.

Because the first decade created a smaller amount of young forest, there will be a very steep climb to meet decade 2 objectives for 10-49 age class.

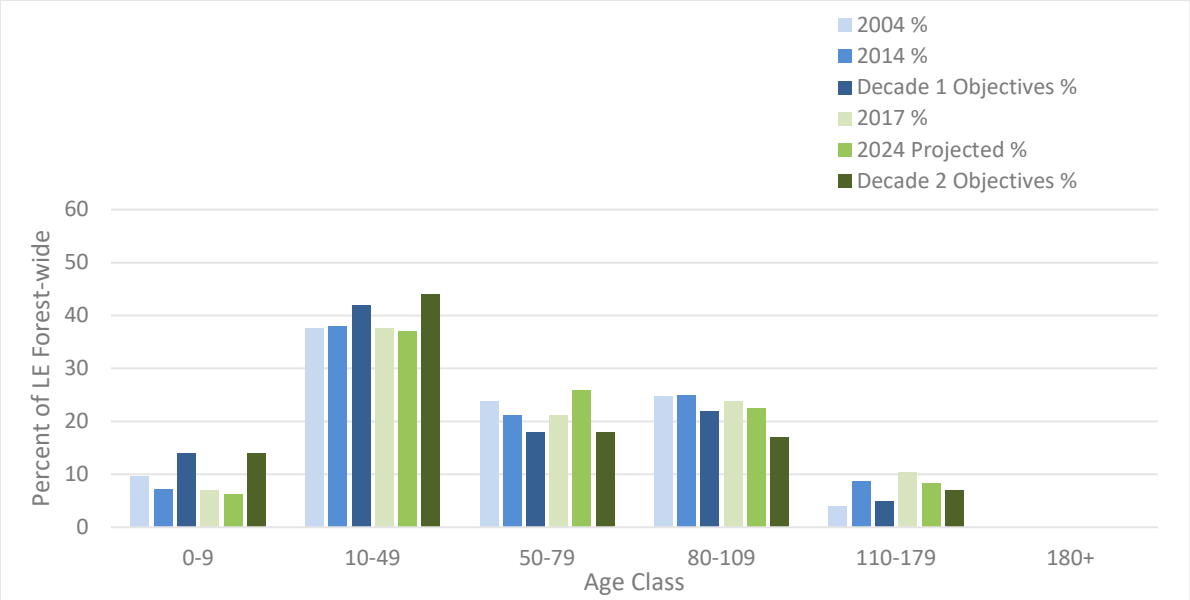


Figure 5.13-4. Jack Pine/Black Spruce LE age class distribution

The JPB LE age class distribution considers Forest Plan objectives for areas outside the BWCAW; however, objectives considered the wilderness conditions at that time (2004). Sixty-six percent of JPB found on the Forest is in the BWCAW, while only 16 percent of the LE is in the general forest management areas (Forest Plan table JPB-5). Since 2004, the BWCAW has experienced multiple stand-replacing fires (Ham Lake Fire, 2007—74,814 acres and Pagami Creek Fire, 2011—93,220 acres), which has increased the amount of young JPB within the wilderness. Considering the new young JPB forest within the BWCAW created from wildfires, reevaluating the young age class objectives across the Forest might now prove less than previously desired.

Dry Mesic Red and White Pine (DRW) Landscape Ecosystem

The percent of young age class (0-9 years) in DRW ended the first decade without enough young forest to meet the objective. The 10-49 age class also fell short of meeting its first decade objective. The mature and older age classes (50-99 years, 100-139 years, and 140-plus years) exceeded their objectives.

The 2017 data shows that young age class acreage has continued to decline; however, with the current treatments proposed, the Forest estimates the young age classes to come very close to meeting the decade 2 objective (figure 5.13-5). In 2017, the 10-49 age class experienced almost no growth and future projections show us coming short of decade 2 objectives because of the young age class reduction and a lack of recruitment from this cohort. Finally, the 2017 data also shows us continuing to exceed the objectives set for age classes 50-99 and 100-139, along with projecting to exceed decade 2 objectives in the future.

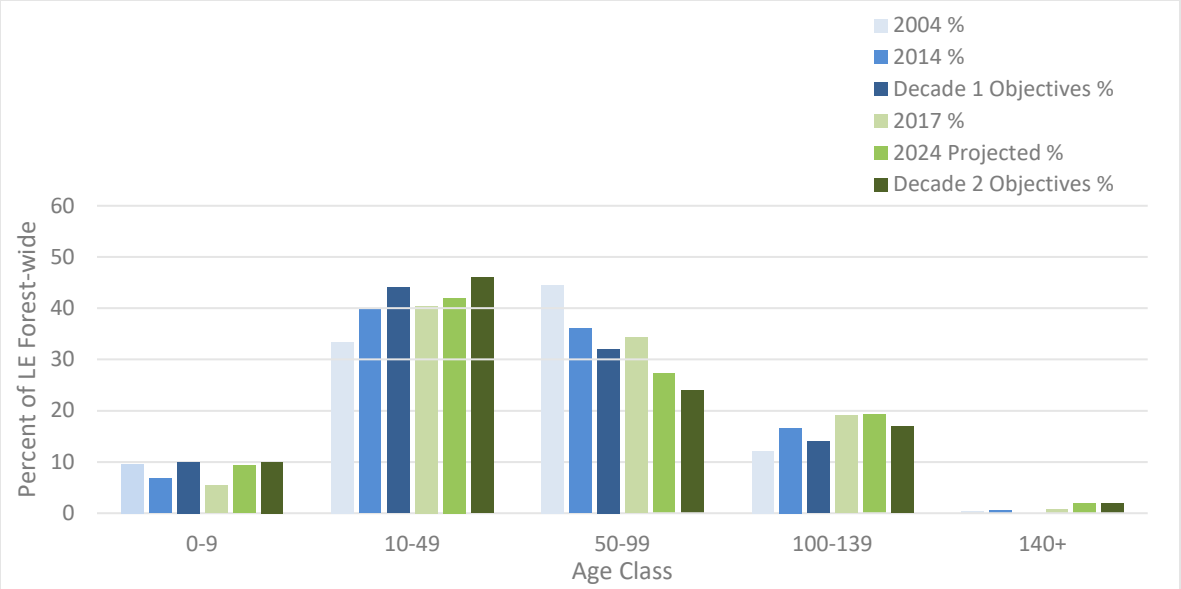


Figure 5.13-5. Dry Mesic Red and White Pine LE age class distribution

Mesic Red and White Pine (MRW) Landscape Ecosystem

The percent of young age class (0-9 years) in the MRW LE was reduced as recommended in the Forest Plan; however, by 2014, the Superior ended the first decade with lower levels of young forest than desired (figure 5.13-6). This trend continues in 2017 as acreage in this age class continues to decline; however, recovery of most of this loss by the end of decade 2 should occur when considering current and proposed treatments.

The 10-49 age class is also falling short of meeting decade 1 objectives, though trending in the right direction. The 2017 data show no growth in acreage for this age class and could fall short of decade 2 objective as well.

There was a steep decline in the 50-79 year age class, meeting decade 1 objectives, and putting us on track to come close to meeting decade 2 objectives.

Older age classes (80-99, 100-119, and 120-plus years) all exceeded decade 1 objectives. In addition, 2017 data shows that their acreages continue to rise. Projections show the likelihood to exceed decade 2 objectives in these age classes.

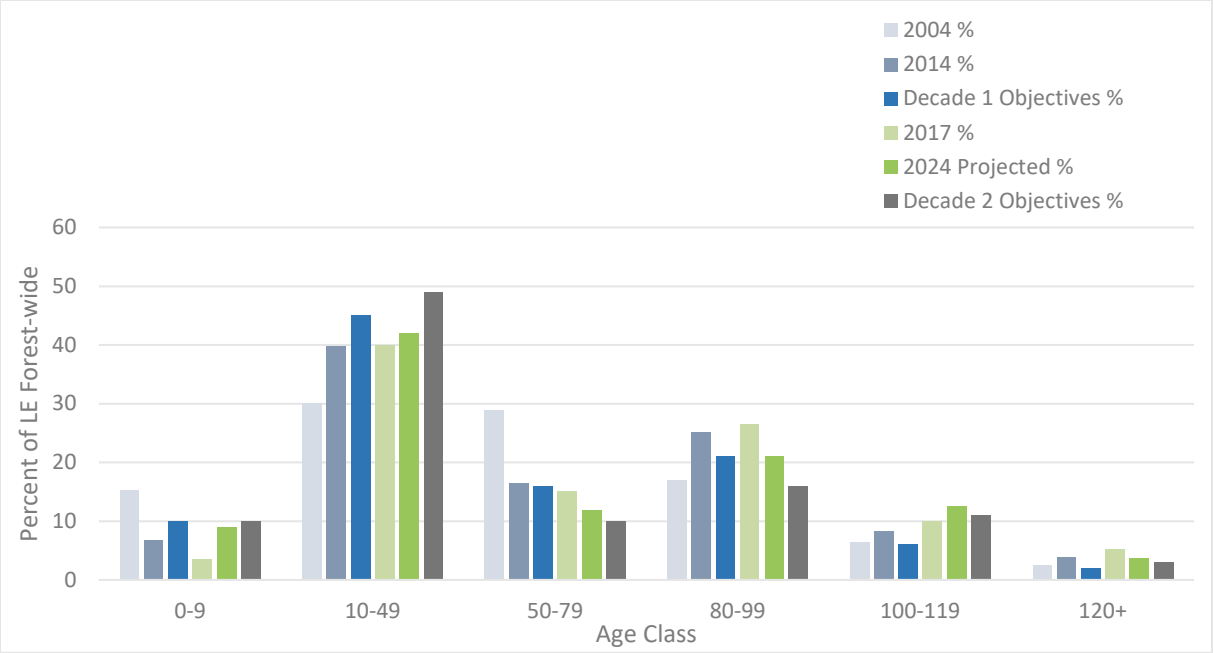


Figure 5.13-6. Mesic Red and White Pine LE age class distribution

Sugar Maple (SMA) Landscape Ecosystem

The percent of young forest (0-9 age class) in the SMA LE decreased by four percent, exceeding decade 1 objectives. There was a simultaneous increase in one of the old age classes (100-149 years), where an exceedance of the objective occurred (monitoring and evaluation report project file). Decade 1 met all other age class objectives and continues to meet decade 2 objectives.

Lowland Conifer (LLC) Landscape Ecosystem

In the lowland conifer LEs, LLC A (lowland conifer within JPB and DRW Landscape Ecosystems) met or are close to meeting all decade 1age class objectives, and are projected to meet decade 2 objectives as well (monitoring and evaluation report project file). The LLC-B (lowland conifer within MRW and MBA LEs) had a reduction of young forest, moving away from the two percent objective for young forest.

In the lowland conifer LEs, the difference between objectives and existing condition are still small and it is difficult to see real trends. The LLC A and B are projected to not have enough young age class to meet decade two objectives, but LLC C (lowland conifer within SMA LE) is projected to have more than enough young to meet objectives. However, by 2024 the Forest expects this trend to recover and move to within one percent of decade 2 objective for young age class. Older age classes in the LLC B are on par and within two - five percent, with the exception of an excess of 80-159 age class projected in 2024 and a four percent reduction in 160-plus age class.

The lowland conifer LEs are comprised of a mixture of black spruce, tamarack, northern white cedar, and lowland hardwoods, including black ash. Given that black spruce and tamarack are both expecting decreases due to climate change and that the Emerald Ash Borer is expanding its range north, it may be difficult to regenerate and maintain these species on the landscape in the future.

Results and Analysis – Vegetation Composition

- Attainment of first decade objectives 2004-2014 – vegetation composition
- Movement towards second decade and long-term objectives 2014-2024 – vegetation composition

Figures 5.13-7 through 5.13-10 display the measured changes in forest composition (also known as forest type) from the beginning of the first decade (2004) to the end of the first decade (2014) to compare Forest Plan objectives. Second decade projections are also included and results are grouped by LE.

On average, the difference between the 2004 conditions and composition objectives is much smaller (one to three percent) than the 2004 conditions and age class objectives (ten to 15 percent). In addition, the trends are smaller and harder to determine.

Generally, forest vegetation composition at the end of decade 2 is trending toward Forest Plan objectives, however often the Forest is still failing to meet the desired mark. This discussion highlights where forest composition for the various LEs was substantially inconsistent with Forest Plan objectives.

In nearly every LE, the jack pine component failed to meet current objectives and is projected to remain below objectives in the second decade, substantially in some LEs. In addition, while white pine tended to meet decade 1 objectives, it is projected to fall short of meeting decade 2 objectives in nearly every LE. A decline in these pine species on the landscape affects the entire ecosystem from the wildlife species that depend on them for both food and shelter to the indirect affects they have on shade and soil acidity. Attempting to change the trajectory and increase their presence on the landscape will mean more investment in planting, restoration; deer browse protection, and site preparation for these species to thrive.

A third species, paper birch, also tended to fall short of decade 1 objectives in every LE, with projections to miss decade 2 objectives. Paper birch is a valued component in each LE not only for wildlife habitat, but for the important structure it can provide within a forest stand, its value as decaying woody debris once it dies, and its cultural significance for providing non-timber forest products.

Alternatively, aspen exceeded decade 1 objectives in every LE and is projected to exceed nearly all decade 2 objectives as well. While its numbers are declining and trending in the right direction, this species remains overabundant on the landscape, making it increasingly difficult to shift the balance in favor of jack pine, as mentioned above.

Spruce and fir met or fall just short of decade 1 objectives. However, by the end of decade 2, they are also projected to exceed objectives in nearly every LE. An overabundance of these species on the landscape creates management concerns despite its importance for some wildlife species because of the heavy shade factor and increased fuel loading. Additionally, these species contribute to the challenge of regenerating less abundant species in each LE.

Mesic Birch/Aspen Spruce/Fir (MBA) Landscape Ecosystem

The MBA LE ended the first decade exceeding objectives for aspen and falling short of spruce and fir. White pine and other species met objectives or came very close. The 2017 data show that these trends, overall, will persist in decade 2 with a few exceptions.

Despite meeting white pine objectives in the first decade, the second decade is not projected to meet objectives. Paper birch projects to fall just short of meeting its decade 2 objectives. Also, while paper birch, quaking aspen, white spruce, black spruce, and balsam fir are all projected to decrease in abundance in northern Minnesota due to climate change (Handler et al. 2014), the mesic soils of this LE could make these areas of the forest more resilient and provide some buffer to the effects of climate change on these species.

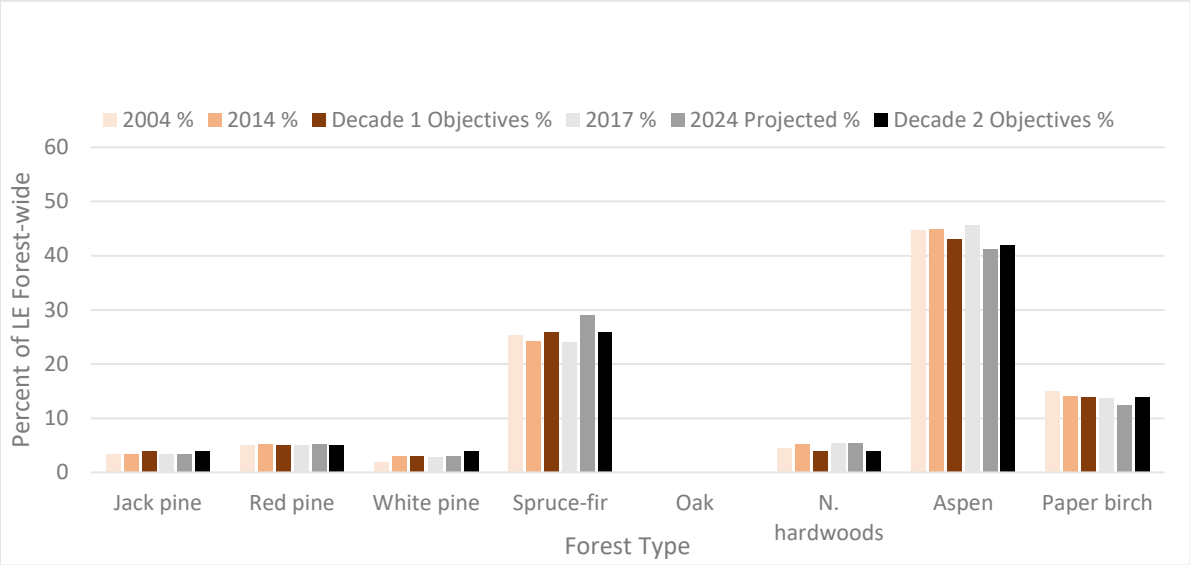


Figure 5.13-7. Mesic Birch/Aspen/Spruce-fir LE-forest type

Jack Pine/Black Spruce (JPB) Landscape Ecosystem

At the end of the first decade, both jack pine and spruce-fir fell short of meeting composition objectives. While other species met or came close to decade 1 objectives, aspen exceeded the goal.

The 2017 and second decade projection data show a continuation of these trends—jack pine continues to decline, even further behind its decade 2 objectives, and aspen continues to remain over-abundant on the landscape. Spruce-fir will also exceed objectives by the end of decade 2. Further, the dry nature of the soils in this LE could exacerbate black spruce's ability to regenerate as this species requires a cool climate and is projected to decrease across the forest with climate change.

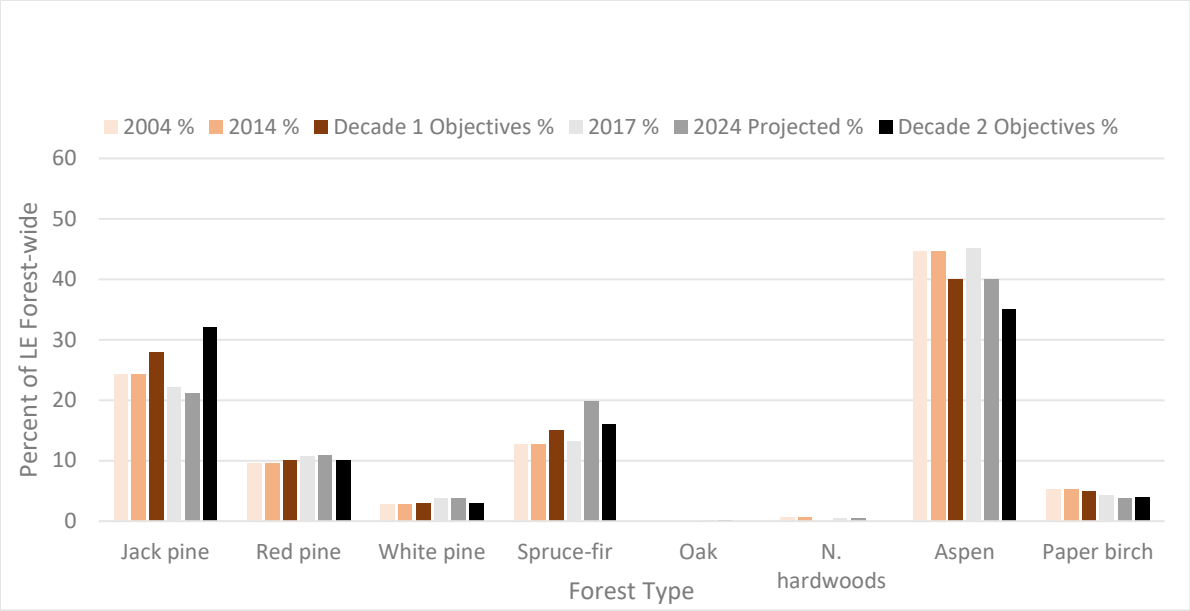


Figure 5.13-8. Jack Pine/Black Spruce LE-forest type

Dry Mesic Red and White Pine (DRW) Landscape Ecosystem

At the end of the first decade, jack pine, spruce-fir, and paper birch all fell short of meeting their objectives; while, red and white pine met their objectives. Aspen continues to remain overabundant in this ecosystem, exceeding decade 1 objectives despite a slight decline over the past decade. Moreover, aspen will remain overabundant by 2024, exceeding decade 2 despite a projected decrease. By the end of the second decade, jack pine, white pine and paper birch are all projected to fall short of meeting their objectives.

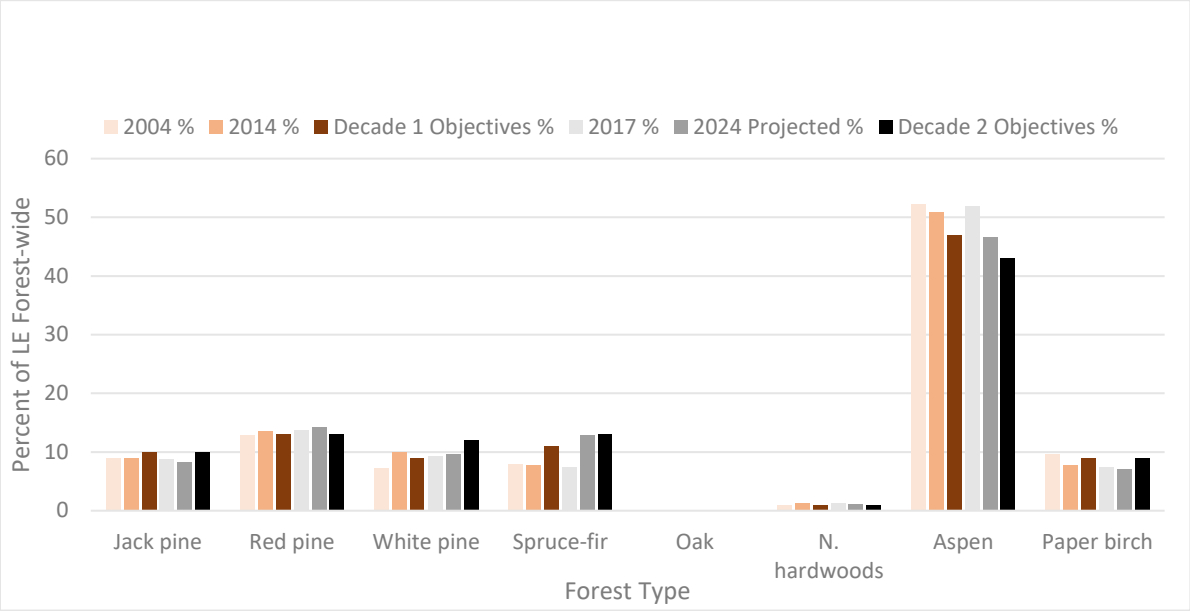


Figure 5.13--9. Dry Mesic Red and White Pine LE-forest type

Mesic Red and White Pine (MRW) Landscape Ecosystem

Jack, red, white pine, and spruce-fir met or came close to meeting their composition objectives at the end of the first decade. Paper birch fell short of meeting objectives, while both aspen and the northern hardwood component exceeded objectives.

Birch will continue to decline by the end of the second decade, moving it even further from meeting its objectives. White pine will remain constant, also falling short of its decade 2 objectives. Although aspen will continue to decline, it will remain overabundant on the landscape by the end of decade 2. The Forest projects spruce-fir to increase some as well and be overabundant by the end of the second decade.

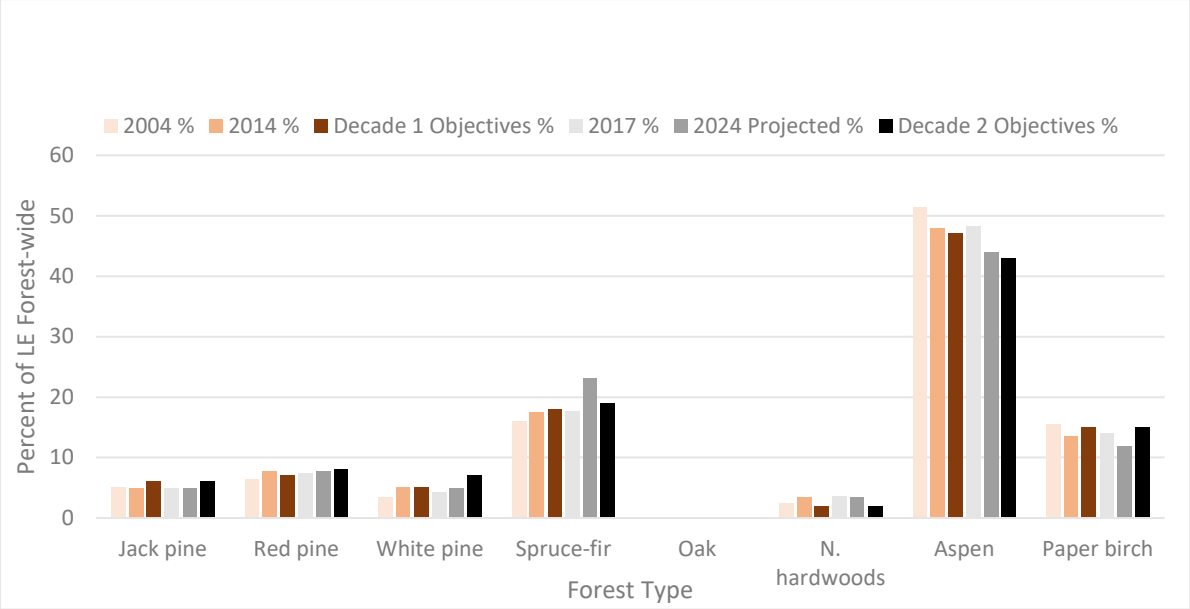


Figure 5.13-10. Mesic Red and White Pine LE-forest type

Results and Analysis - Tree Species Diversity

Objectives for tree species diversity differ from forest type objectives in that they address the percent of tree species in a stand rather than the dominant tree species at the stand level. Tree species diversity is important because the higher number of ecosystem functions it fulfills in a stand, than the stand can adapt better to changing conditions.

Forest staff measure objectives for tree species diversity in different ways including:

- Forest stand type changes due to a shift in the stand's dominant tree species.
- Forest stand types dominated by multiple species.
- Stand and structure composition resulting from overstory removal by different harvest methods and removal quantities.
- Seedling amounts of planted species (does not account for species the Superior does not plant, i.e., aspen, balsam fir).

Aspen

Objectives are to decrease aspen in all upland LEs. Forest management is on track with this objective for aspen tree species diversity. The amount of acres dominated only by aspen (FT91) decreased in the first decade by almost 20,000 acres. In addition, the amount of acres that are dominated by a mix of aspen, white spruce, balsam fir, and paper birch (FT95) increased by nearly 17,000 acres. Given these results, Forest managers should continue to find opportunities to decrease aspen.

Paper Birch

Objectives are to increase paper birch in LEs dominated by early successional species: JPB and MBA. Forest management is not on track for objectives for paper birch tree species diversity. In the other upland LEs, the objective is to maintain paper birch. Paper birch has decreased slightly in the first decade (potentially due to paper birch sites being good for white pine conversions—white pine increased in acreage in the first decade as described below.) The Forest planed minor amounts of paper birch seedlings to diversify stands or supplement natural paper birch regeneration (124,000 seedlings). Given these results, Forest managers should continue to seek opportunities to increase prevalence of paper birch within mixed forest stands for diversity, and promote pure paper birch stands.

Jack Pine

Objectives are to increase jack pine in all upland LEs, except MBA where the objective is to maintain or reduce the 2004 level of jack pine. At the end of the first decade, there was very little change for the jack pine forest type across all LEs. In the first decade, the Forest planted 579,000 jack pine seedlings to diversify composition. Given these results, in the following decade, Forest managers should seek to place greater emphasis on increasing jack pine both within mixed stands to increase diversity and to convert more sites to jack pine. The Forest can look to have similar success for jack pine objectives as it did for white pine in decade 1, emphasizing jack pine where appropriate.

Black Spruce Upland

Objectives are to maintain or increase black spruce in the upland LEs, with the exception of JPB where the desired future condition is to maintain or decrease 2004 levels. Forest management is meeting objectives for tree species diversity for upland black spruce. These stands consists of two different stages of development: in mesic sites in the understory through stand development, and on dry sites as a pioneer species at stand origin. There was a small increase for stands typed as upland black spruce/black spruce-jack pine mix following the Forest planting 234,000 black spruce seedlings in the first decade.

Red Pine

Objectives are to maintain or increase red pine in all upland LEs. Forest management is meeting objectives for tree species diversity for red pine. The DRW and MRW LEs experiences the biggest growth change. At the end of the first decade, single-species red pine stands experienced little to no growth change. Despite this, the Forest planted 2,570,000 red pine seedlings in the first decade, mostly with one or more other species. Given these results, Forest managers should continue to find opportunities to increase this species where appropriate.

White Pine

All upland LEs have objectives for increasing white pine. By the end of the first decade, stands typed at white pine (FT3, 30) increased by 7,000 acres, and includes 5,866,000 planted white pine seedlings. The Forest planted seedlings both as a single species to convert stands to white pine and with one or more other species to increase within-stand diversity. Forest management is meeting objectives for tree species diversity for white pine.

Tamarack and White Cedar

All upland LEs have objectives for increasing tamarack and white cedar. There was no change in the stand acres typed as tamarack; however, the Forest planted 98,000 tamarack seedlings in the first decade. The amount of acres typed as cedar or mixed cedar increased very slightly in the first decade. In addition, the Forest planted approximately 85,000 cedar seedlings across the SNF. The Forest typically plants tamarack and cedar with two or more other species rather than as a single species in stands. Forest management is meeting the objectives for tree species diversity for these species.

White Spruce

All upland LEs have objectives for increasing white spruce. There was very little change in the acres typed as white spruce (FT8, 16, 23); however, the Forest planted around 2,250,000 white spruce seedlings in the first decade. Forest management is meeting the objectives for tree species diversity for white spruce.

Balsam Fir

All upland LEs, except the Sugar Maple (SMA) LE have objectives to decrease balsam fir. The Superior NF does not artificially regenerate balsam fir, but it easily becomes established in the understory of stands that do not experience disturbance. Forest inventory analysis (FIA) evaluates species abundance over time (USDA 2018) and found an increase in balsam fir regeneration on all ownerships in the Laurentian Mixed Forest Province. It is likely then that balsam fir has also increased in upland LEs to some degree. Forest management is not meeting objectives for tree species diversity for this species.

Red Maple

Objectives for red maple are mixed. In the JPB LE, the desired condition is to reduce red maple, while in the DRW LE; it is to increase the species. Forest inventory analysis evaluates species abundance over time (USDA 2018), and found a sharp increase in red maple regeneration and advanced regeneration on all ownerships in the Laurentian Mixed Forest Province. It is likely then that red maple has also increased in upland LEs to some degree. Forest managers should continue to monitor this species for better understanding to meet related tree species diversity objectives.

Results and Analysis – Management Indicator Habitat (MIH)

Figure 5.13-11 displays the relationship of management indictor habitats (MIH) to overall wildlife habitat. There are eight upland forested management indicator habitat types (MIH 1-8) and one lowland forest indicator habitat type (MIH 9). Forest Plan objectives are for three different age groups for each MIH: young, mature, and old/ old-growth/ multi-aged. The forest types and ages for these groups vary by species and are located in Appendix C of the Forest Plan.

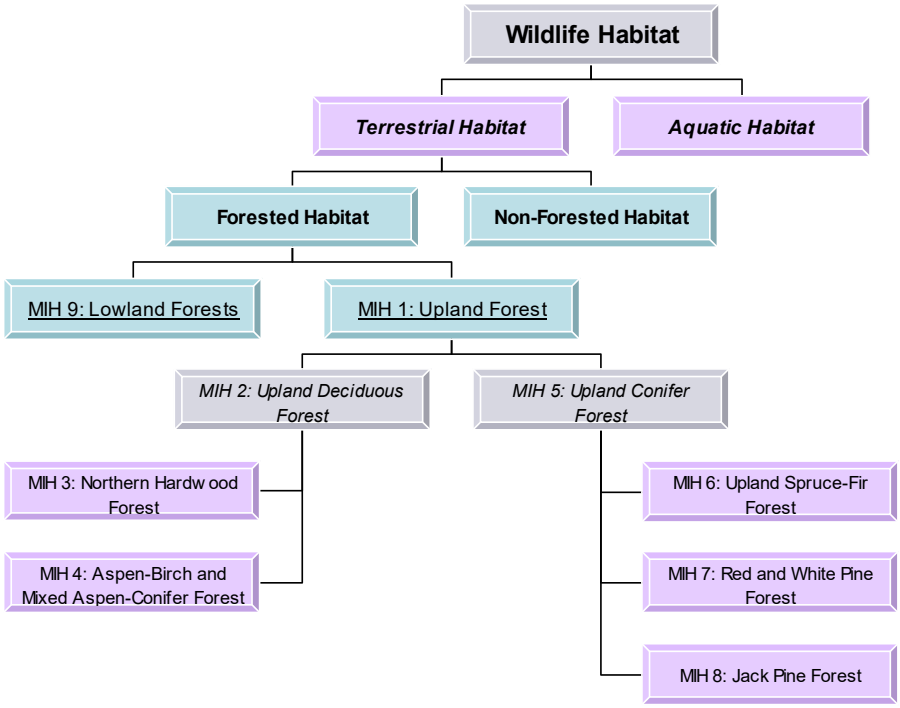


Figure 5.13-11.Management indicators habitats of the Superior National Forest Plan

The following figures display the measured changes (+ = increase, - = decrease, m = maintain) in the percent of each MIH from the beginning of the first decade (2004) to the end of the first decade (2014), as compared to the objectives stated in the Forest Plan. Second decade projections are also included and compare the change from 2004 to 2024. Results are grouped by LE; however, some general trends were observed across the Forest. The monitoring and evaluation project record has more detailed information about results in appendix *Veg-B Management Indicator Habitats.*

By the end of the first decade, three LEs stand out as having the greatest deviations from Forest Plan objectives, including the MBA, JBP and DRW LEs. These three LEs consistently showed a lower than desired level amount of young forest particularly young aspen, birch, mixed aspen-conifer, and jack pine. In addition, they contain consistently higher levels of the oldest aspen, birch, and the mixed aspen and conifer-forest indicator habitats. Vegetation management efforts should emphasize creating more young aspen, birch, mixed aspen-conifer and jack pine and reducing the oldest aspen habitat types (particularly the MBA, JBP and DRW LE) to manage for the desired balance of indicator habitats into the second decade.

Mesic Birch/Aspen Spruce/Fir (MBA) Landscape Ecosystem

Attainment of first decade objectives 2004-2014 – MIH

The MBA LE ended the first decade with 18 of 24 (75 percent) of upland MIH age groups showing trends consistent with Forest Plan objectives (table 5.13-2). There were a few notable exceptions, as discussed below. After the first decade of Forest Plan implementation, the primary indicator habitat type of concern is the amount of young and oldest aspen-birch and mixed aspen conifer forest habitat in the MBA LE.

Table 5.13-2. Achievement of first decade objective trends for the percent of young, mature, and older forest indicator habitats in the MBA LE from 2004-2014*

Number	Management Indicator Habitat	LE age: Young	LE age: Mature	LE age: Old/Multi-aged
1	Upland forest	-	-	+
2	Upland deciduous	-	-	+
3	Northern hardwoods	m	-	+
4	Aspen-birch	-	-	+
5	Upland conifer	-	-	+
6	Upland spruce-fir	-	-	+
7	Red & white pine	-	+	+
8	Jack pine	m	-	-

Gray cells show MIH trends that met Forest Plan objectives for decade 1 (associated data can be found in Monitoring and Evaluation Report project file)

(+ = increase, - = decrease; m = maintain from 2004 condition)

Young Upland Forest Indicator Habitats

The Forest achieved and exceeded decade 1 objectives to decrease the overall percent of young upland forest habitat (figures 5.13-12 and 5.13-13). Young, upland conifer forest is a relatively small habitat component in the MBA LE. Young spruce-fir, red, and white pine forest habitats are less common; while, young jack pine forest habitats are more common in this landscape at the end of the first decade. This is consistent with the decade 1 objectives for these upland, conifer habitat types (figures 5.13-12 and 5.13-13).

The reduced amount of young deciduous forest habitat, particularly young aspen-birch and mixed aspen conifer forest, is a concern for young, upland forest habitat in the MBA LE at the end of the first decade. There is less young, upland aspen habitat in this landscape today than a decade ago, which runs counter to the desired first decade objective trends (figures 5.13-12 and 5.13-13). Northern hardwood habitat is a minor component of this LE and the reverse trend is not a concern at the LE or Forest scale (figure 5.13-13).

Mature Forest Indicator Habitats

A decade 1 objective is to decrease mature forest habitat in the MBA LE. This was achieved with a reduction from 28 percent in 2004 to 16 percent in 2014 (figure 5.13-12). The largest reduction occurred in the mature upland aspen-birch and mixed aspen conifer forest indicator habitats as a result primarily of forest growth and succession into old, old growth, and multi-aged stages (figure 5.13-13). Although this trend is consistent with Forest Plan objectives, it also indicates missed opportunities to manage these mature forests for a higher amount of desired young aspen-birch and mixed aspen conifer forest habitat in the first decade. Mature spruce-fir habitat increased, where the Plan outlined a desired decrease. However, this increase did not affect the overall decreasing trend of mature upland forest habitat in the MBA LE due to its small size.

Old, Old growth, and Multi-aged Indicator Habitats

The Forest achieved and exceeded decade 1 objectives to increase old, old growth, and multi-aged upland forest habitat in all indicator habitats (figures 5.13-12 and 5.13-13). Although the increasing trend is consistent with Forest Plan objectives, it also indicates missed opportunities to manage these older forests habitat for more desired young aspen-birch and mixed aspen conifer forest habitat in the first decade.

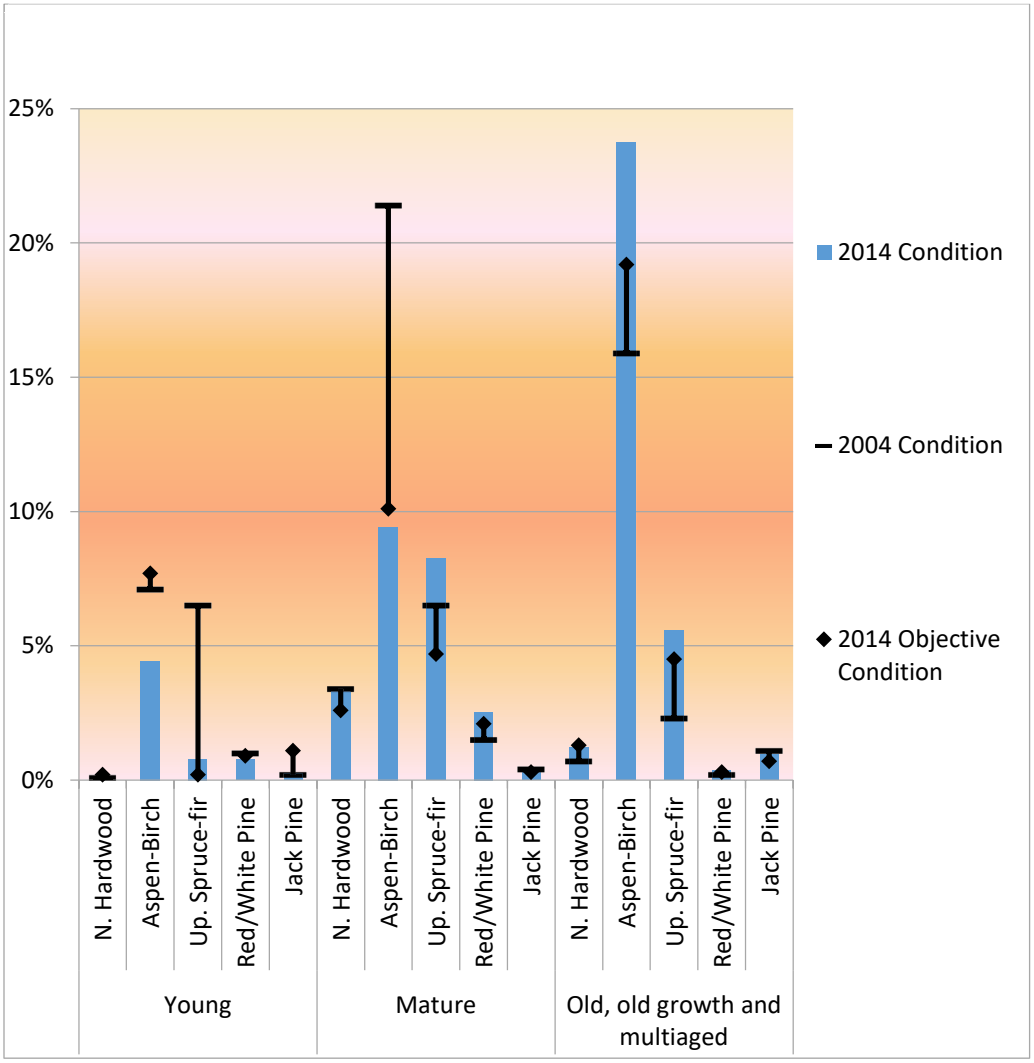


Figure 5.13-13. Achievement of objectives for management indicator habitat in the Mesic Birch/Aspen/Spruce/Fir LE: Decade 1

Movement towards second decade and long-term objectives 2014-2024 – MIH

Projections for the second decade in the MBA LE show 17 of 24 (71 percent) of upland MIH age groups showing trends consistent with Forest Plan objectives (figure 5.13-14 and 5.13-15). This is down from 75 percent at the end of the first decade. A few notable exceptions exists as discussed below. Of greatest concern is the continued trajectory of young and oldest aspen-birch, mixed aspen conifer forest habitat, and to a lesser extent young jack pine habitat (figure 5.13-15). Although table 5.13-3 displays the Forest meeting objectives to increase the oldest aspen-birch and mixed conifer forest, figure 5.13-15 shows that this indicator habitat will exceed

objective levels by a substantial amount. Without increased management of the old, old growth aspen-birch, and mixed aspen conifer forest to create more young of this habitat type, the MBA LE is at risk of losing a large component of this habitat type through succession to upland spruce-fir dominated habitats.

Table 5.13-3. Progress towards second decade objective trends for the percent of young, mature, and older forest indicator habitats in the MBA LE from 2004-2024*

#	Management Indicator Habitat	Young: Dec 2 Objective	Young: 2017 Actual	Mature: Dec 2 Objective	Mature: 2017 Actual	Old/Multi-aged: Dec 2 Objective	Old/Multi-aged: 2017 Actual
1	Upland forest	-	-	-	-	+	+
2	Upland deciduous	+	-	-	-	+	+
3	N. hardwoods	+	+	-	m	+	+
4	Aspen-birch	+	-	-	-	+	+
5	Upland conifer	-	-	+	+	+	+
6	Upland spruce-fir	-	-	-	+	+	+
7	Red & white pine	-	-	+	+	+	+
8	Jack pine	+	-	+	-	-	-

*Gray cells show MIH trends that are projected in 2024 to be on track for achieving Forest Plan Objectives for Decade 2 (associated data can be found in Monitoring and Evaluation Report project file)

**Decade 2 Objective trend for age of MIH (+ = increase, - = decrease; m = maintain from 2004 condition)

Young Upland Forest Indicator Habitats

Although the Forest is meeting decade 2 objectives for a decrease in young upland forest habitat over all (MIH 1), some concern remains for current and projected trends of young in some habitat types. The Forest should work at substantially increasing the development of young aspen-birch, mixed aspen conifer forest, and to a lesser extent jack pine forest in the MBA LE (figure 5.13-15).

Mature Forest Indicator Habitats

The amount of mature upland forest habitat in the MBA LE continues to show an overall downward trend, consistent with second decade objectives. However, mature upland spruce-fir forest habitat is increasing rather than a desired decreasing trend (table 5.13-3 and 5.13-13). This increase is likely due to the succession of very old aspen forest to spruce-fir forests over the past 13 years of Forest Plan implementation. This trend may not be reversible in the second decade; however, restoration of appropriate mature spruce-fir forest to young mixed aspen conifer forest habitat could slow it in the longer term.

Old, Old growth, and Multi-aged Indicator Habitats

Monitoring data shows that the Forest is meeting decade 2 objectives for all old, old growth, and multi-aged forest habitat in MBA LE (table 5.13-3 and 5.13-13), with the amount of very old

forest increasing across the landscape. However, a concern remains in the second decade with an excess of the oldest aspen-birch, mixed aspen conifer, and upland spruce-fir forest (figure 5.13-13). This overabundance is the primary contributing factor to the imbalance of the desired mix of all indicator habitats in the MBA LE. To achieve this balance in this LE, the Forest needs to manage the oldest aspen and birch, mixed aspen conifer, and upland spruce-fir forest to create and restore young aspen and birch, and mixed aspen conifer habitat.

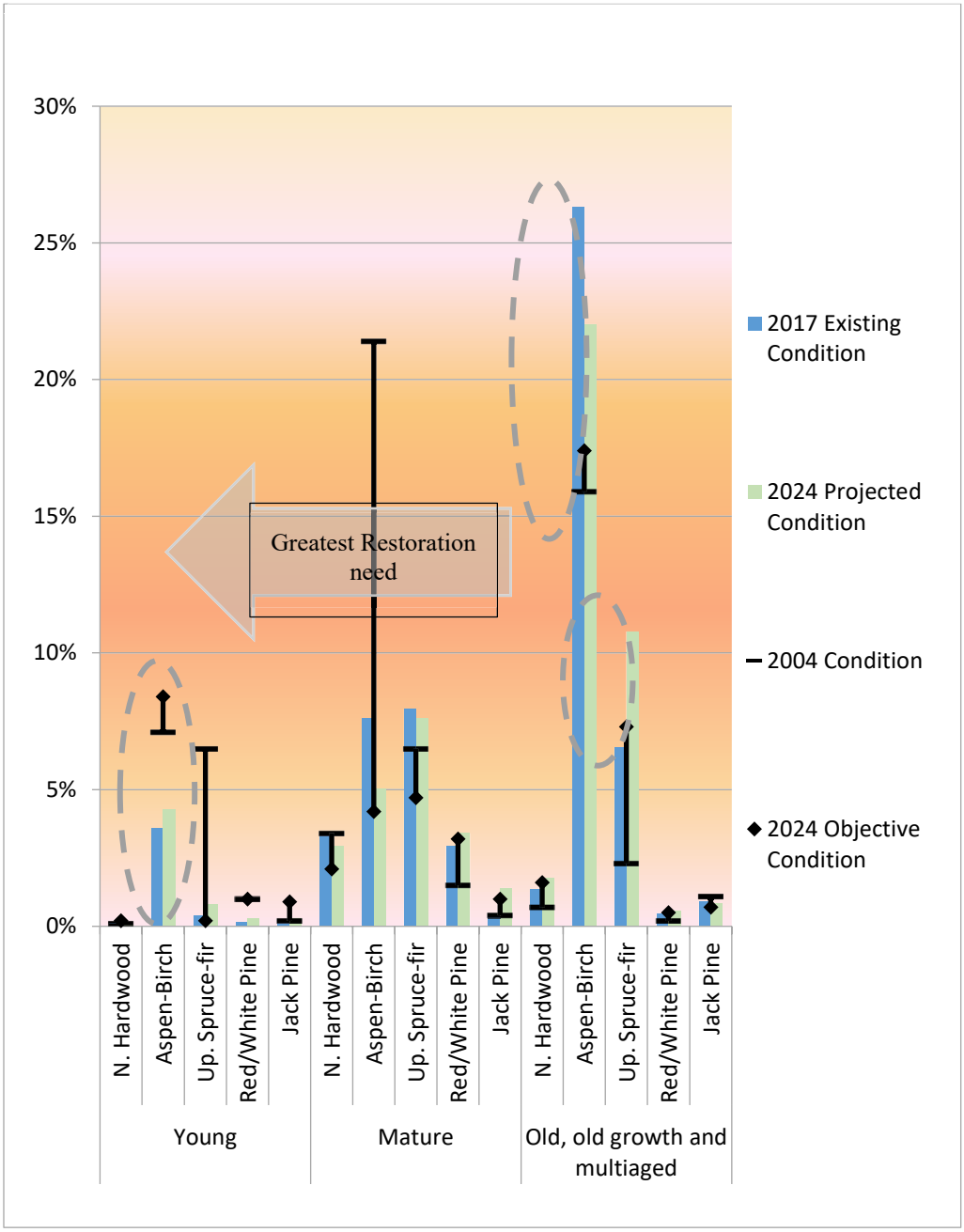


Figure 5.13-14. Progress towards objectives for management indicator habitat in the Mesic Birch/Aspen/Spruce/Fir LE: Decade 2

Jack Pine/Black Spruce (JPB) Landscape Ecosystem

Attainment of first decade objectives 2004-2014 – MIH

The JPB LE ended the first decade with 12 of 24 (50 percent) of upland MIH age groups showing trends consistent with Forest Plan objectives (table 5.13-4, figure 5.13-15, and project file). After the first decade of Plan implementation, the primary habitat type of concern is the young and oldest jack pine, and to a lesser extent young and oldest aspen-birch and mixed aspen conifer forest habitat in the JPB LE.

Table 5.13-4. Achievement of first decade objective trends for the percent of young, mature, and older forest indicator habitats in the JPB LE from 2004-2024*

Number	Management Indicator Habitat	Young	Mature	Old/Multi-aged
1	Upland forest	+	-	-
2	Upland deciduous	+	-	-
3	Northern hardwoods	-	+	m
4	Aspen-birch	+	-	-
5	Upland conifer	+	+	+
6	Upland spruce-fir	-	-	+
7	Red & white pine	-	+	+
8	Jack pine	+	+	-

*Gray cells show MIH trends that met Forest Plan Objectives for Decade 1 (associated data located in the Monitoring and Evaluation project record)

Decade 1 Objective trend for age of MIH (+ = increase, - = decrease; m = maintain from 2004 condition)

Young Upland Forest Indicator Habitats

The Forest did not achieve decade 1 objectives to increase young upland forest habitat in the JPB LE (table 5.13-4, figure 5.13-15, and project file). Of particular concern is the reduced amount of young jack pine forest habitat and to a lesser extent young aspen-birch and mixed aspen conifer forest (table 5.13-4 and figure 5.13-15). These habitat types not only decreased in the JPB LE but occurred at even lower levels than a decade ago.

Mature Forest Indicator Habitats

The Forest maintained the amount of mature forest habitat in the JPB LE in the first decade rather than a desired decrease achieved (table 5.13-4, figure 5.13-15, and project file). Moreover, a large reduction in mature upland aspen-birch and mixed aspen conifer forest indicator habitats resulted from forest growth and succession into old, old growth, and multi-aged stages (figure 5.13-15 and project file). Without the desired decrease, the mature spruce-fir habitat increased, contributing to the maintenance of mature forest over all. Northern hardwood habitat is a minor component of this LE and the reverse trend is not a concern at the LE or Forest scale (figure 5.13-15 and project file).

Old, Old growth, and Multi-aged Indicator Habitats

First decade objectives to decrease old, old growth, and multi-aged upland forest habitat overall was not achieved (table 5.13-3, figure 5.13-15, and project file). This condition resulted from of an abundance of old, old growth, and multi-aged aspen-birch and mixed aspen conifer and jack pine forest habitat (figure 5.13-15 and project file). These trends represent missed opportunities to manage these older forest habitats for more young jack pine and some aspen-birch and mixed aspen conifer forest habitats.

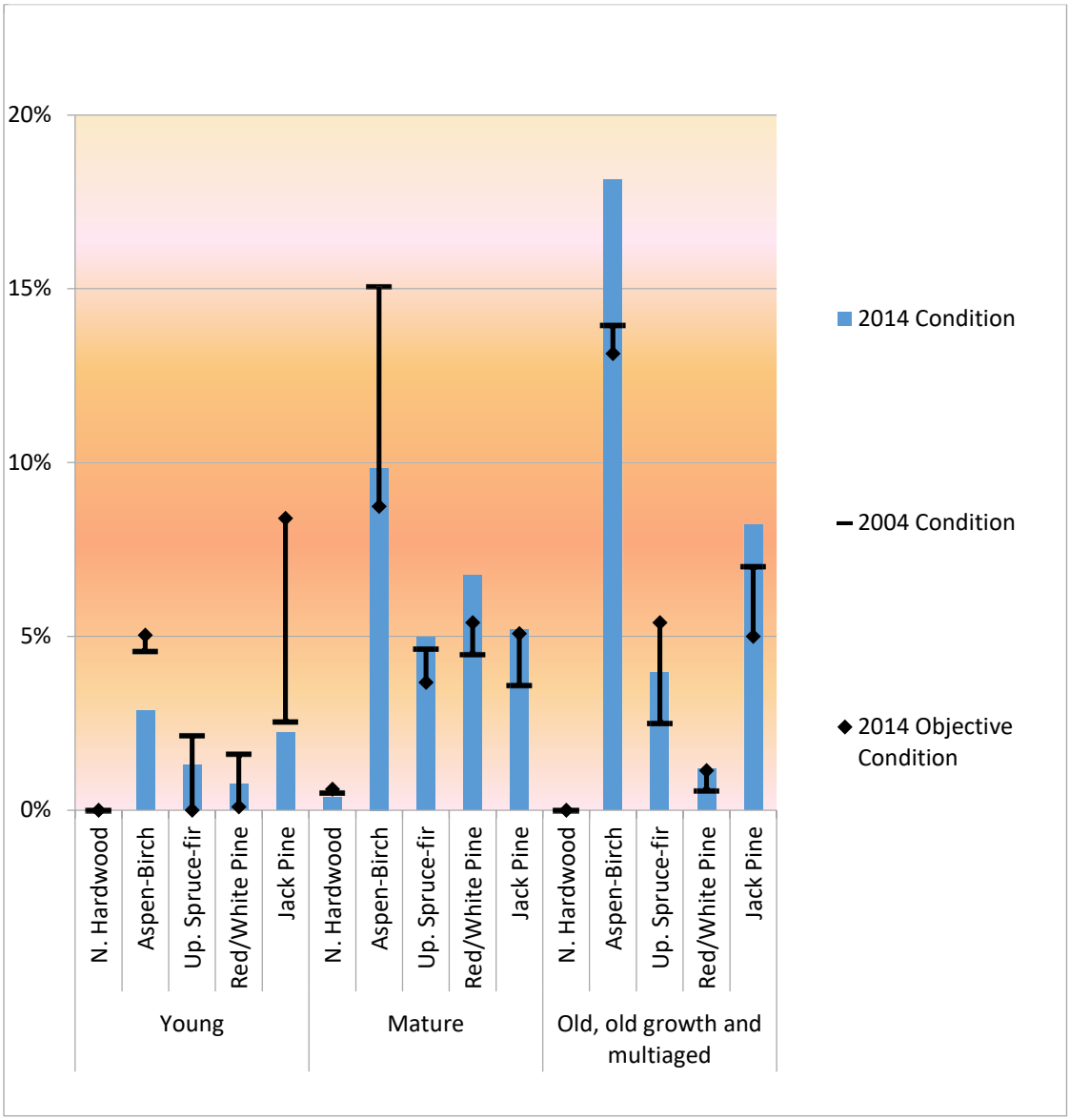


Figure 5.13-15. Achievement of objectives for management indicator habitat in the Jack Pine/Black Spruce LE: Decade 1

Movement towards second decade and long-term objectives 2014-2024 – MIH

Projections for the second decade in the JPB LE show 14 of 24 (58 percent) of upland MIH age groups showing trends consistent with Forest Plan objectives (Figure 5.13-15, 5.13-16 and project file). This is up from 50 percent at the end of the first decade, while notable exceptions

are discussed below. Of greatest concern is the continued trajectory of the young and oldest jack pine forest and to a lesser extent aspen-birch, mixed aspen conifer forest habitat (figure 5.13-16). Although figure 5.13-15 shows that the Forest is on track for meeting objectives to decrease the oldest jack pine and aspen-birch, mixed conifer habitats, figure 5.131.16 shows that these indicator habitats will fall short of objective levels by a substantial amount. Without increased management of the very old aspen-birch, mixed aspen conifer forest, and jack pine forest to create more young of these habitat types, the JPB LE is at risk of losing this habitat component through succession to upland spruce-fir dominated habitats.

Table 5.13-5. Progress towards second decade objective trends for the percent of young, mature, and older forest indicator habitats in the JPB LE from 2004-2024*

#	Management Indicator Habitat	Young: Dec 2 Objective	Young: 2017 Actual	Mature: Dec 2 Objective	Mature: 2017 Actual	Old/Multi-aged: Dec 2 Objective	Old/Multi-aged: 2017 Actual
1	Upland forest	+	-	-	+	-	+
2	Upland deciduous	+	-	-	-	-	+
3	N. hardwoods	-	-	m	-	+	+
4	Aspen-birch	+	-	-	-	-	+
5	Upland conifer	+	-	+	+	+	+
6	Upland spruce-fir	-	-	-	+	+	+
7	Red & white pine	-	-	+	+	+	+
8	Jack pine	+	-	+	+	-	+

Gray cells show MIH trends that are projected in 2024 to be on track for achieving Forest Plan Objectives for Decade 2 (associated data can be found in the Monitoring and Evaluation project record)

Decade 2 Objective trend for age of MIH (+ = increase, - = decrease; m = maintain from 2004 condition)

Young Upland Forest Indicator Habitats

The Forest is not meeting objective trends for increased young jack pine on the landscape. In addition, to a lesser extent, it is not meeting it for aspen-birch and mixed aspen conifer forest habitat in the JPB LE (table 5.13-5 and 5.13-16). The Forest should substantially increase the development of young jack pine and to a lesser extent aspen-birch and mixed aspen conifer forest habitat in the JPB LE to achieve the desired mix of indicator habitats across this LE.

Mature Forest Indicator Habitats

The Forest is not meeting objective trends for decreasing mature forest habitat in the JPB LE, primarily due to an increase in mature upland spruce-fir in this landscape (table 5.13-5 and figure 5.13-16). This increase is likely due to the succession of very old aspen forest to spruce-fir forests over the past 13 years of Forest Plan implementation. This trend may not be reversible in the second decade; however, restoration of appropriate mature spruce-fir forest to young mixed aspen conifer forest habitat could slow the trend in the longer term. Additionally, allowing more of this habitat type to mature and provide older upland spruce-fir forest habitat in the future could also slow the trend.

Old, Old growth, and Multi-aged Indicator Habitats

Monitoring data show that the Forest is not meeting decade 2 objectives for some old, old growth, and multi-aged forest habitats in the JPB LE (table 5.13-5 and figure 5.13-16). In addition, the amount of very old forest is increasing across this landscape. There remains a concern in the second decade with an excess of the oldest aspen-birch, mixed aspen conifer, and jack pine forest (figure 5.13-16). This overabundance is the primary contributing factor achieving the desired mix of all indicator habitats in the JPB LE. The Forest needs management and treatment of the oldest aspen and birch, mixed aspen conifer, and jack pine forest to create and restore young aspen-birch, mixed aspen conifer, and jack pine habitat to restore the desired balance of habitat in the JPB LE.

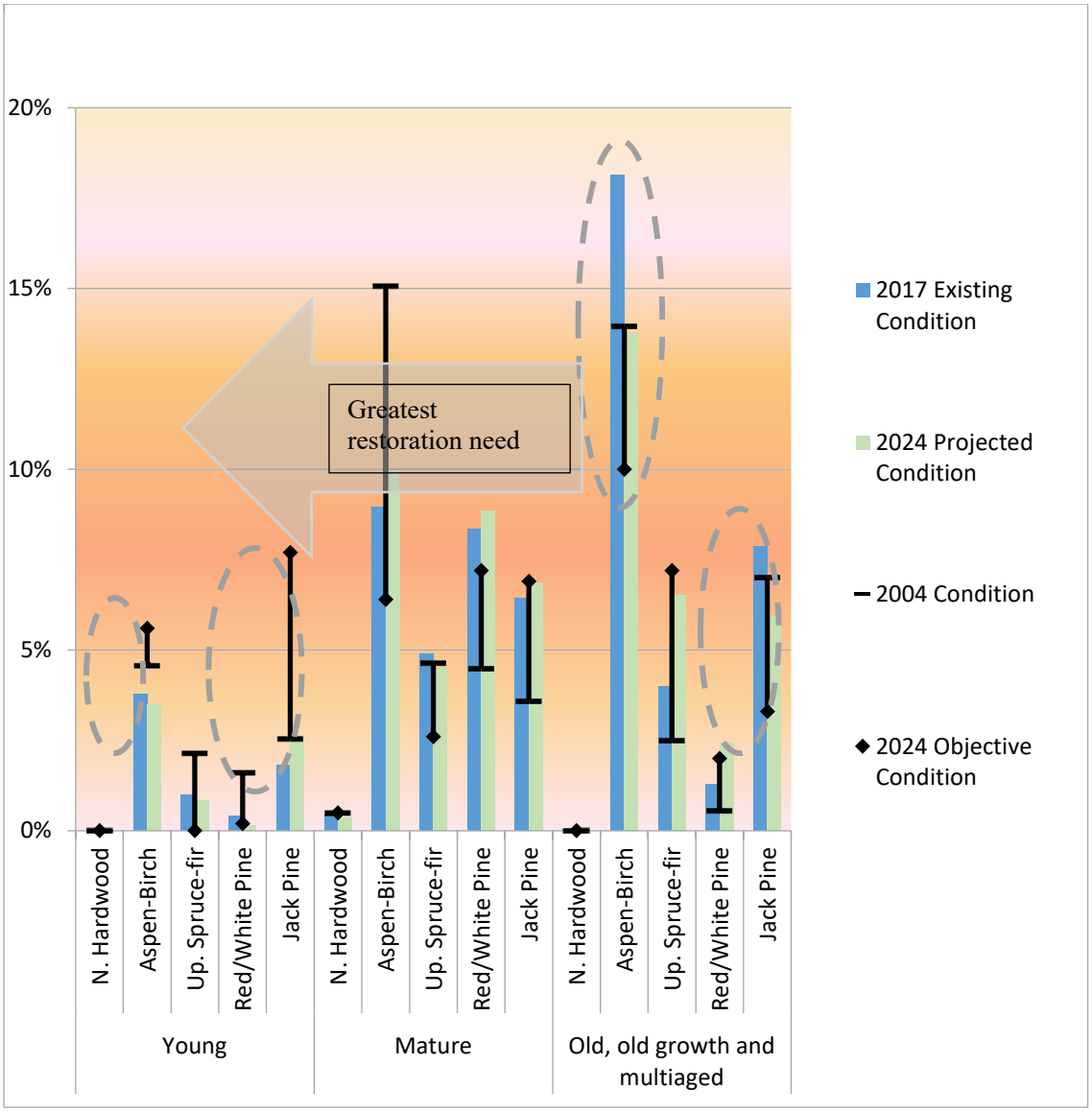


Figure 5.13-16. Progress towards management indicator habitat objectives in the Jack Pine/Black Spruce LE: Decade 2

Dry Mesic Red and White Pine (DRW) Landscape Ecosystem

Attainment of first decade objectives 2004-2014 – MIH

The DRW LE ended the first decade with 17 of 24 (71 percent) of upland MIH age groups showing trends consistent with Forest Plan objectives (Figure 5.13-17). There were a few notable exceptions that are with a discussed below. After the first decade of Plan implementation, the primary habitat types of concern is under achievement of the desired amount of young and oldest jack pine forest and to a lesser extent aspen-birch and mixed aspen conifer forest habitat in the DRW LE as illustrated by figure 5.13-17, although desired trend directions where achieved for most (figure 5.13-17).

Table 5.13-6. Achievement of first decade objective trends for the percent of young, mature, and older forest indicator habitats in the DRW LE from 2004-2014*

Number	Management Indicator Habitat	Young	Mature	Old/Multi-aged
1	Upland forest	-	-	+
2	Upland deciduous	-	-	-
3	Northern hardwoods	+	-	m
4	Aspen-birch	-	-	-
5	Upland conifer	-	-	+
6	Upland spruce-fir	-	-	+
7	Red & white pine	-	-	+
8	Jack pine	+	+	-

* Gray cells show MIH trends that met Forest Plan Objectives for Decade 1 (associated data located in the Monitoring and Evaluation Report project file)

Decade 1 Objective trend for age of MIH (+ = increase, - = decrease; m = maintain from 2004 condition)

Young Upland Forest Indicator Habitats

The Forest achieved and exceeded decade 1 objectives to decrease young upland forest habitat (table 5.13-6 and figure 5.13-17). The young, upland conifer forest is a relatively small habitat component in the DRW LE. Young spruce-fir, red and white pine forest habitats are less common in this landscape today – consistent with the decade 1 objectives for these upland conifer habitat types (figure 5.13-17). A reduced amount of young jack pine forest is concerning for young upland forest habitat in the DRW LE at the end of the first decade. First decade objectives look to increase the amount of young jack pine forest on the landscape (figure 5.13-17). However, the counter trend is not a concern within the LE or Forest due to the minor component of northern hardwood in this LE (figure 5.13-17).

Mature Forest Indicator Habitats

The Forest achieved the decade 1 objective to decrease mature forest habitat in the MBA LE during 2014 (table 5.13-6 and figure 5.13-17). The largest reduction occurred in the mature upland aspen-birch and the mixed aspen conifer forest indicator habitats (figure 5.13-17). The changes to the northern hardwood, red and white pine forest habitats was likely a result of database-type changes and had no realized change in habitat availability on the landscape (figure

5.13-17). In addition, these increases minimally affected the overall decreasing trend of mature habitat in the DRW LE.

Old, Old growth, and Multi-aged Indicator Habitats

The Forest achieved decade 1 objectives to increase old, old growth, and multi-aged upland forest habitat (table 5.13-6 and figure 5.13-17). After the first decade, there was a higher amount of old, old growth, and multi-aged aspen-birch and mixed aspen conifer forest habitat than desired (figure 5.13-17). Despite this, monitoring also shows a positive decreasing trend in old jack pine forest; however, the amount is higher than expected (figure 5.13-17). These data indicate missed opportunities to manage these older forests habitat for more desired jack pine and young aspen-birch and mixed aspen conifer forest habitat in the first decade.

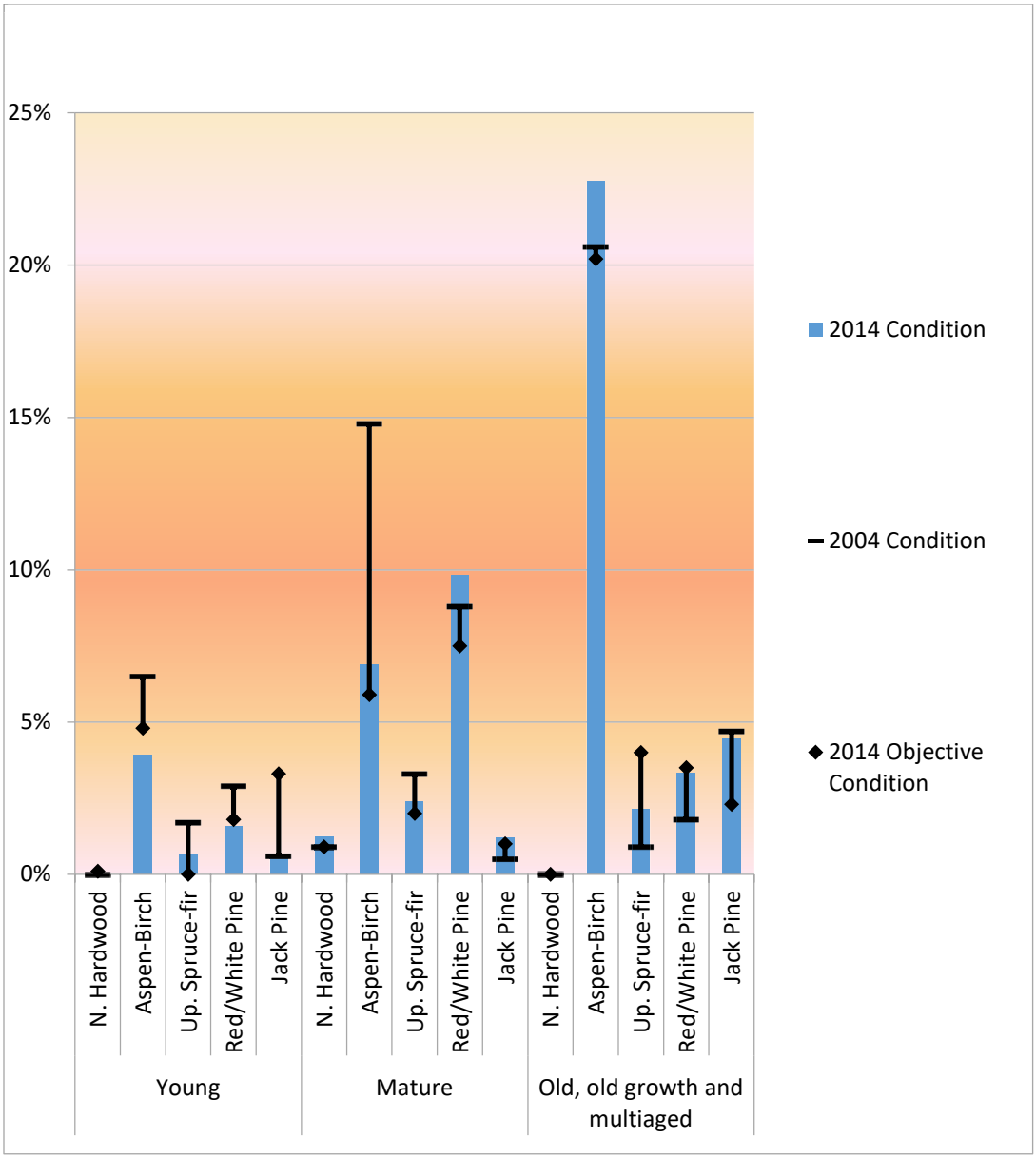


Figure 5.13-17. Achievement of objectives for management indicator habitat in the Dry-mesic Red and White Pine LE: Decade 1

Movement towards second decade and long-term objectives 2014-2024 – MIH

Projections for the second decade in the DRW LE show 19 of 24 (79 percent) of upland MIH age groups showing trends consistent with Forest Plan objectives (table 5.13-7 and figure 5.13-18). This is up from 71 percent at the end of the first decade. Of all the landscape ecosystems, the DRW appears to be one of three in the best condition for MIH objectives and shows the lowest restoration needs for the second decade. A goal for this LE is to continue to maintain the desired balance and manage the older jack pine forest habitat to promote the underrepresented upland spruce-fir conditions.

Table 5.13-7. Progress towards second decade objective trends for the percent of young, mature, and older forest indicator habitats in the DRW LE from 2004-2024

#	Management Indicator Habitat	Young: Dec 2 Objective	Young: 2017 Actual	Mature: Dec 2 Objective	Mature: 2017 Actual	Old/Multi-aged: Dec 2 Objective	Old/Multi-aged: 2017 Actual
1	Upland forest	-	-	-	-	+	+
2	Upland deciduous	+	-	-	-	-	+
3	N. hardwoods	+	-	-	+	m	+
4	Aspen-birch	+	-	-	-	-	+
5	Upland conifer	-	-	-	+	+	+
6	Upland spruce-fir	-	-	-	-	+	+
7	Red & white pine	-	-	-	+	+	+
8	Jack pine	+	-	+	+	-	-

Gray cells show MIH trends that are projected in 2024 to be on track for achieving Forest Plan Objectives for Decade 2 (associated data can be found in Monitoring and Evaluation Report project file)

Decade 2 Objective trend for age of MIH (+ = increase, - = decrease; m = maintain from 2004 condition)

Young Upland Forest Indicator Habitats

The Forest is meeting objective trends for decreasing young forest habitat in the DRW LE (table 5.13-7 and figure 5.13-18). Despite some concern for young upland deciduous and jack pine habitat from 2017 trends, the Forest will meet all decade objectives if full implementation of all planned projects occurs.

Mature Forest Indicator Habitats

The Forest is meeting objective trends for decreasing mature forest habitat in the DRW LE (table 5.13-7 and figure 5.13-18). Although the current and projected trends in mature northern hardwood, red, and white pine are contradictory to second decade objectives, these habitats are a minor component of the DRW LE at the Forest scale and do not impact the overall trend for all upland mature forest.

Old, Old growth, and Multi-aged Indicator Habitats

The Forest is maintaining old upland forest, and maintaining each indicator habitat as well (with the exception of northern hardwoods that make up a very small component of the DRW LE). The projected trend for overall old upland forest is for an under representation of older upland

spruce-fir habitat. The Forest should consider options to restore and promote old and multi-aged spruce-fir forest conditions in the oldest jack pine forest habitats (figure 5.13-18).

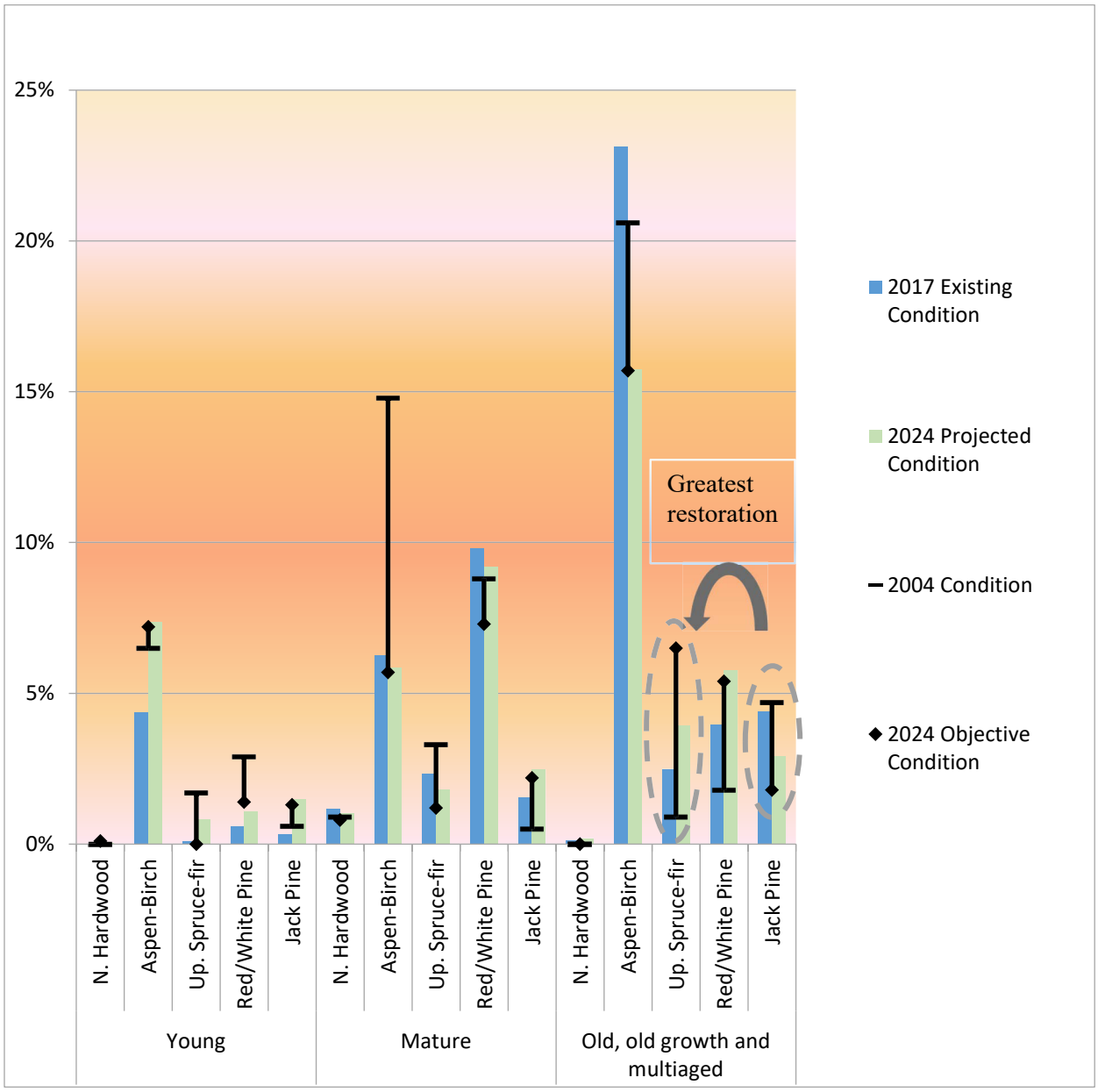


Figure 5.13-18. Progress towards objectives for management indicator habitat in the Dry-mesic Red and White Pine LE: Decade 2

Mesic Red and White Pine (MRW) Landscape Ecosystem

Attainment of first decade objectives 2004-2014 – MIH

The MRW LE ended the first decade with 16 of 24 (67 percent) of upland MIH age groups showing trends consistent with Forest Plan objectives (table 5.13-8). There were a few notable exceptions as discussed below. After the first decade of Plan implementation, the primary habitat types of concern are the under achieved desired amounts of young and oldest aspen-birch, mixed aspen conifer forest, and to a lesser extent mature upland spruce-fir habitat in the MRW

LE (figure 5.13-19). However, desired trend amounts overall were achieved for most MIHs (table 5.13-8).

Table 5.13-8. Achievement of first decade objective trends for the percent of young, mature, and older forest indicator habitats in the MRW LE from 2004-2014*

#	Management Indicator Habitat	Young	Mature	Old/Multi-aged
1	Upland forest	-	-	+
2	Upland deciduous	-	-	+
3	Northern hardwoods	m	-	+
4	Aspen-birch	-	-	+
5	Upland conifer	-	-	+
6	Upland spruce-fir	-	-	+
7	Red & white pine	-	+	+
8	Jack pine	m	-	-

* Gray cells show MIH trends that met Forest Plan Objectives for Decade 1 (associated data is located in the Monitoring and Evaluation Report project file)

Decade 1 Objective trend for age of MIH (+ = increase, - = decrease; m = maintain from 2004 condition)

Young Upland Forest Indicator Habitats

The Forest achieved decade 1 objectives to decrease young upland forest habitat (table 5.13-8 and figure 5.13-19). Contradictory trends in young northern hardwood, jack, red and white pine are insignificant at the Forest and LE scale having negligible effect on habitat availability at that scale. Although the decreased trend in upland young aspen-birch and mixed aspen conifer is consistent with Forest Plan objectives, the Forest created less young aspen-birch and mixed aspen-conifer forest in the first decade of Forest Plan implementation than desired (figure 5.13-19).

Mature Forest Indicator Habitats

The SNF achieved the decade 1 objective to decrease the overall amount of mature forest habitat in the MRW LE (table 5.13-8 and table 5.13-19). The largest reduction occurred in the mature upland aspen-birch and mixed aspen-conifer forest indicator habitats from forest growth and succession into old, old growth, and multi-aged stages. Although this trend is consistent with Forest Plan objectives, it also indicates missed opportunities to manage these mature forests for more desired young aspen-birch and mixed aspen-conifer forest habitat in the first decade. Mature northern hardwood, spruce-fir, and jack pine habitats increased, where the Plan called for a decrease. Despite this, the increase was small and did not affect the overall decreasing trend of mature habitat in the MRW LE (figure 5.13-19).

Old, Old growth, and Multi-aged Indicator Habitats

The SNF achieved decade 1 objectives to increase old, old growth, and multi-aged upland forest habitat in all indicator habitats (table 5.13-8 and figure 5.13-19). The end of the first decade had large amounts of old, old growth, and multi-aged aspen-birch and mixed aspen conifer forest habitat (figure 5.13-19). While consistent Forest Plan objectives, the Forest needs to manage this older forests habitat for more desired young aspen-birch and mixed aspen conifer forest habitat in the first decade. In addition, the old jack pine forest habitat increased, where a decreasing

trend was desired (figure 5.13-19). However, the small amount of old jack pine is likely insignificant at the Forest and LE scale.

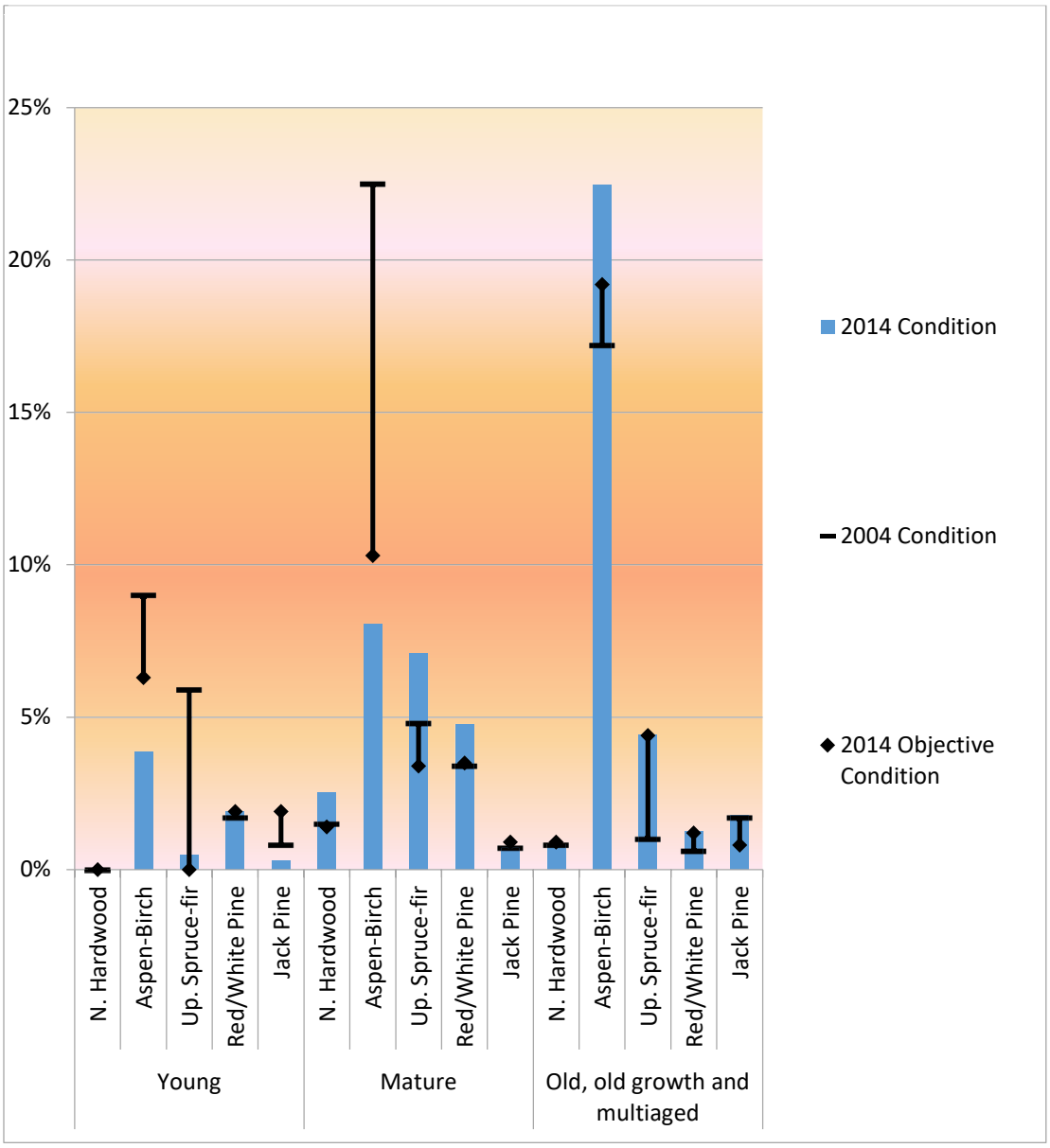


Figure 5.13-19. Achievement of objectives for management indicator habitat in the Mesic Red and White Pine LE: Decade 1

Movement towards second decade and long-term objectives 2014-2024 – MIH

Projections for the second decade in the MRW LE show 19 of 24 (79 percent) of upland MIH age groups are consistent with Forest Plan objectives (table 5.13-9 and figure 5.13-20). This is up from 67 percent at the end of the first decade. A few notable exceptions are discussed below. Of all the LEs, the MRW appears to be one of three in the best condition for MIH objectives and shows the lowest restoration needs for the second decade. The Forest should continue to manage the desired balance for this LE.

Table 5.13-9. Progress towards second decade objective trends for the percent of young, mature, and older forest indicator habitats in the MRW LE for 2004-2024*

#	Management Indicator Habitat	Young: Dec 2 Objectives	Young: 2017 Actual	Mature: Dec 2 Objectives	Mature: 2017 Actual	Old/Multi-aged: Dec 2 Objectives	Old/Multi-aged: 2017 Actual
1	Upland forest	-	-	-	-	+	+
2	Upland deciduous	-	-	-	-	+	+
3	N. Hardwoods	m	m	-	+	+	+
4	Aspen-birch	-	-	-	-	+	+
5	Upland conifer	-	-	-	+	+	+
6	Upland spruce-fir	-	-	-	+	+	+
7	Red & white pine	-	-	+	+	+	+
8	Jack pine	m	-	+	+	-	+

*Gray cells show MIH trends that are projected in 2024 to be on track for achieving Forest Plan Objectives for Decade 2 (associated data can be found in Monitoring and Evaluation Report project file)

Decade 2 Objective trend for age of MIH (+ = increase, - = decrease; m = maintain from 2004 condition)

Young Upland Forest Indicator Habitats

The amount of young upland forest habitat in the MRW LE is consistent with second decade objectives with a downward trend (table 5.13-9 and figure 5.13-20). Both northern hardwood and jack pine forest habitats are projected to show a slight increase rather than maintain 2004 levels. However, given their minor representation in the MRW LE, these opposing trends will not affect the overall habitat trend for young upland forest (figure 5.13-20).

Mature Forest Indicator Habitats

The Forest is achieving second decade objectives to decrease mature forest habitats in the MRW LE (tables 5.13-9 and figure 5.13-20). Northern hardwood forest is projected to show a slight increase rather than a desired decrease. However, given its minor representation in the MRW LE, this opposing trend will not affect the overall habitat trend for mature upland forest. The Forest also anticipates spruce-fir forest habitat to increase rather than decrease (table 5.13-9 and figure 5.13-20). Despite this, projected trends from the 2017 condition show a decrease and decade 2 management activities could further decrease mature upland spruce-fir (table 5.13-9 and figure 5.13-20).

Old, Old growth, and Multi-aged Indicator Habitats

The Forest is achieving decade 2 objectives to increase the amount of old, old growth, and multi-aged upland forest habitat in all indicator habitats and decrease them in jack pine forest habitat (table 5.13-9 and figure 5.13-20). The Forest needs to restore the habitat balance in the MRW LE through management of the oldest aspen-birch, mixed aspen conifer, and spruce-fir forests to create and restore young aspen-birch, mixed aspen confer, and jack pine habitat.

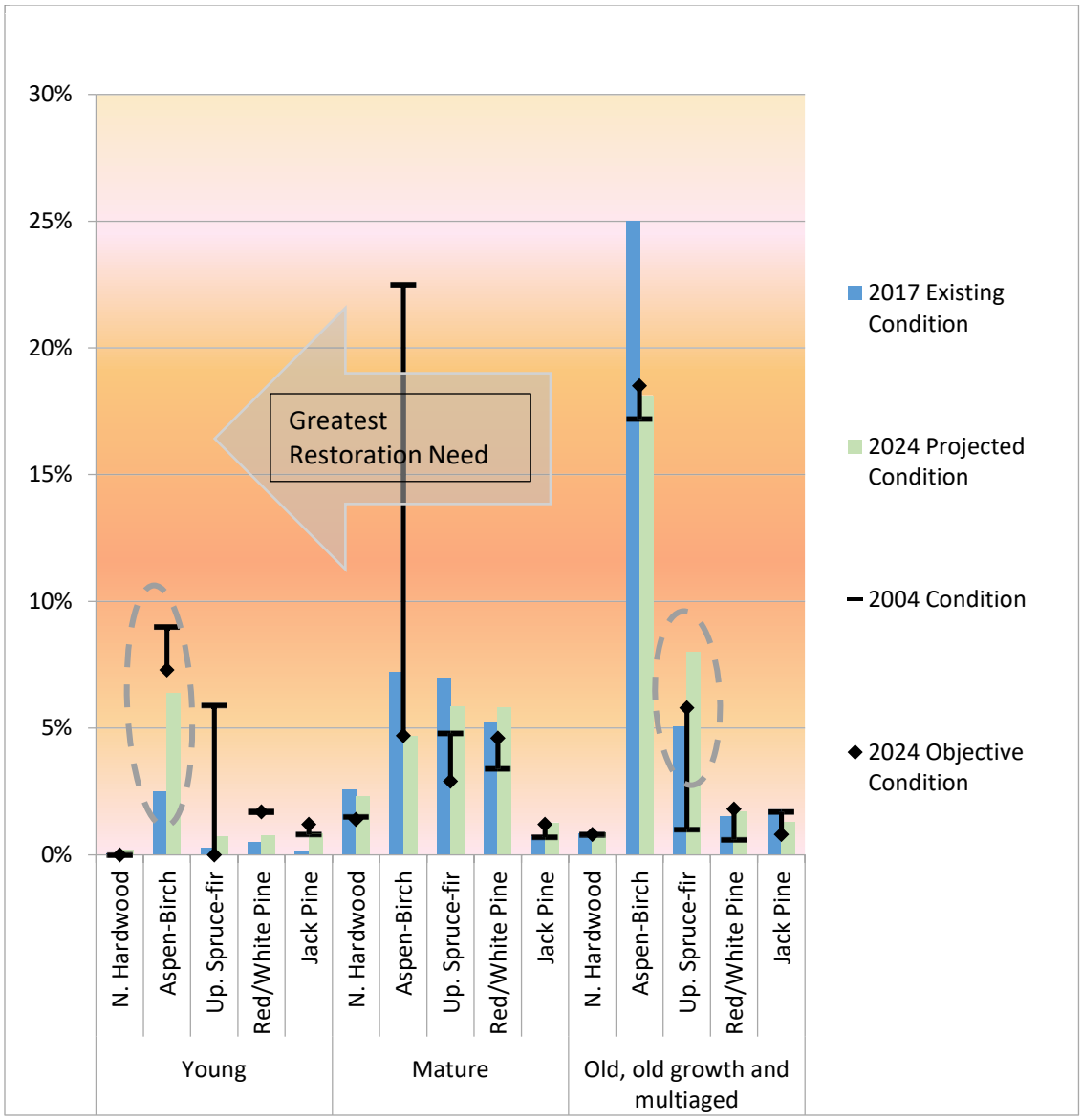


Figure 5.13-20. Progress towards objectives for management indicator habitat in the Mesic Red and White Pine LE: Decade 2

Sugar Maple (SMA) Landscape Ecosystem

Attainment of first decade objectives 2004-2014 – MIH

The SMA LE ended the first decade with 19 of the 24 (79 percent) of upland MIH age groups showing trends consistent with Forest Plan objectives (figures 5.13-21 and 5.13-22). There were a few notable exceptions that are with a discussed below. No habitat types were identified as a concern or of highest restoration need at the end of the first decade of Forest Plan implementation.

Table 5.13-10. Achievement of first decade objective trends for the percent of young, mature, and older forest indicator habitats in the SMA LE from 2004-2014*

Number	Management Indicator Habitat	Young	Mature	Old/Multi-aged
1	Upland forest	-	-	+
2	Upland deciduous	-	-	+
3	Northern hardwoods	-	-	+
4	Aspen-birch	-	-	+
5	Upland conifer	-	m	+
6	Upland spruce-fir	-	-	+
7	Red & white pine	+	+	m
8	Jack pine	m	+	m

*Gray cells show MIH trends that met Forest Plan Objectives for Decade 1 (associated data is in the Monitoring and Evaluation Report project file)

Decade 1 Objective trend for age of MIH (+ = increase, - = decrease; m = maintain from 2004 condition)

Young Upland Forest Indicator Habitats

The Forest achieved and exceeded decade 1 objectives to decrease young upland forest habitat (table 5.13-10 and figure 5.13-21). The decade ended with less young aspen-birch and mixed aspen conifer forest habitat in this landscape than in 2004 and less than predicted by 2014. This is likely due to the reduced amount of vegetation management that occurred in the first 10 years of implementing the Forest Plan.

Mature Forest Indicator Habitats

The SNF achieved the decade 1 objective to decrease mature forest habitat in the MBA LE (table 5.13-10 and figure 5.13-21) The largest reduction occurred in the mature northern hardwood, aspen-birch, and mixed aspen conifer forest indicator habitats from forest growth and succession into old, old growth, and multi-aged stages. Mature spruce-fir habitat increased, where the Forest desired a decrease, and jack pine forest habitat decreased, where an increase was desired. However, given the small amounts of these habitats in the SMA LE, they had no impact on the overall decreasing trend of mature habitat (figure 5.13-21).

Old, Old growth, and Multi-aged Indicator Habitats

The Forest achieved decade 1 objectives to increase old, old growth, and multi-aged upland forest habitat in all indicator habitats (table 5.13-10 and figure 5.13-21). Trends in the oldest jack, red and white pine forest habitat ran counter to desired first decade trends. However, given the small amounts of these habitats in the SMA LE, they had no impact on the overall increasing trend of mature habitat (figure 5.13-21).

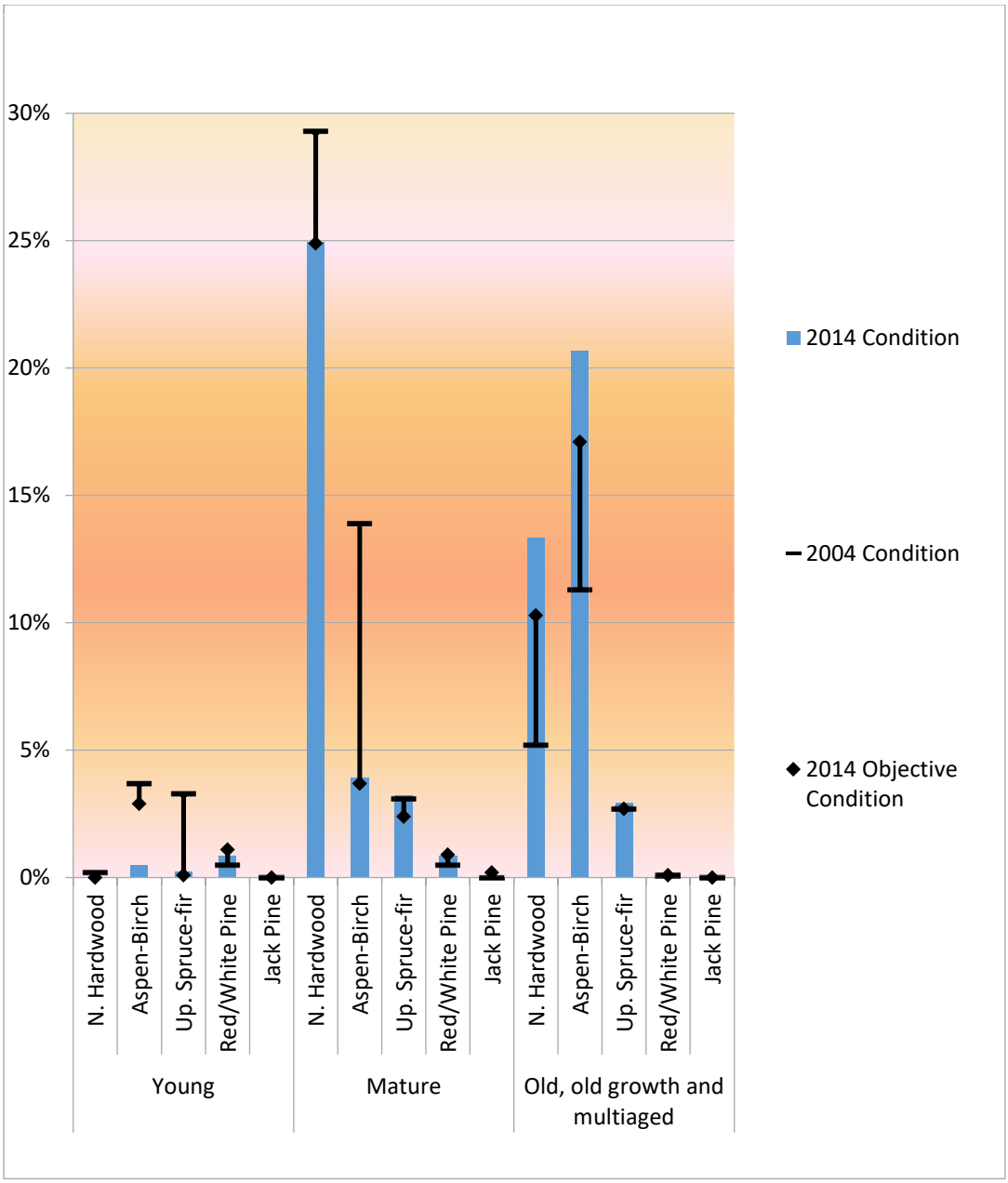


Figure 5.13-21. Achievement of objectives for management indicator habitat in the Sugar Maple LE: Decade 1

Movement towards second decade and long-term objectives 2014-2024 – MIH

Projections for the second decade trends in the SMA LE show 17 of 24 (71 percent) of upland MIH age groups showing consistent with Forest Plan objectives (figures 5.13-21 and 5.13-22). This is down from 19 of 24 (79 percent) at the end of the first decade. The few notable exceptions are discussed below. Of all the landscape ecosystems, the SMA appears to be one of three in the best condition for MIH objectives and shows the lowest restoration needs for the second decade. Although the number of MIHs with projected trends displays a decline with second decade objectives, there does not appear to be an obvious restoration need for this LE. Continuing to manage to maintain the desired balance could be the goal for this LE.

Table 5.13-11. Progress towards second decade objective trends for the percent of young, mature, and older forest indicator habitats in the SMA LE from 2004-2024*

#	Management Indicator Habitat	Young: Dec 2 Objectives	Young: 2017 Actual	Mature: Dec 2 Objectives	Mature: 2017 Actual	Old/Multi-aged: Dec 2 Objectives	Old/Multi-aged: 2017 Actual
1	Upland forest	-	-	-	-	+	+
2	Upland deciduous	-	-	-	-	+	+
3	N. hardwoods	-	-	-	-	+	+
4	Aspen-birch	-	-	-	-	+	+
5	Upland conifer	-	-	+	+	+	+
6	Upland spruce-fir	-	-	-	-	+	+
7	Red & white pine	-	-	-	+	+	+
8	Jack pine	m	m	+	m	m	+

Gray cells show MIH trends that are projected in 2024 to be on track for achieving Forest Plan Objectives for Decade 2 (associated data can be found in Monitoring and Evaluation Report project file)

Decade 2 Objective trend for age of MIH (+ = increase, - = decrease; m = maintain from 2004 condition)

Young Upland Forest Indicator Habitats

Young upland forest habitat in the SMA LE continues to show an overall downward trend, consistent with second decade objectives (table 5.13-11 and figure 5.13-22) Both northern hardwood and aspen forest habitats are projected to show a slight increase rather than decrease from 2004 levels. However, given the total amount of young forest in the SMA LE, the opposing trends do not affect to overall habitat trend for young upland forest (figure 5.13-22).

Mature Forest Indicator Habitats

The Forest is maintaining second decade objectives for a decrease in mature forest habitats in the SMA LE (table 5.13-11 and figure 5.13-22). Spruce-fir, red and white pine forest habitats are projected to show a slight increase rather than a desired decrease, and jack pine habitat is projected to be maintained rather than to increase. However, given the small amount of these habitat types in the SMA LE, the opposing trend will not affect to overall habitat trend for mature upland forest.

Old, Old growth, and Multi-aged Indicator Habitats

The Forest is maintain decade 2 objectives to increase old, old growth, and multi-aged upland forest habitat in all indicator habitats, with a slight increase in jack pine forest habitat (table 5.13-11 and figure 5.13-22)

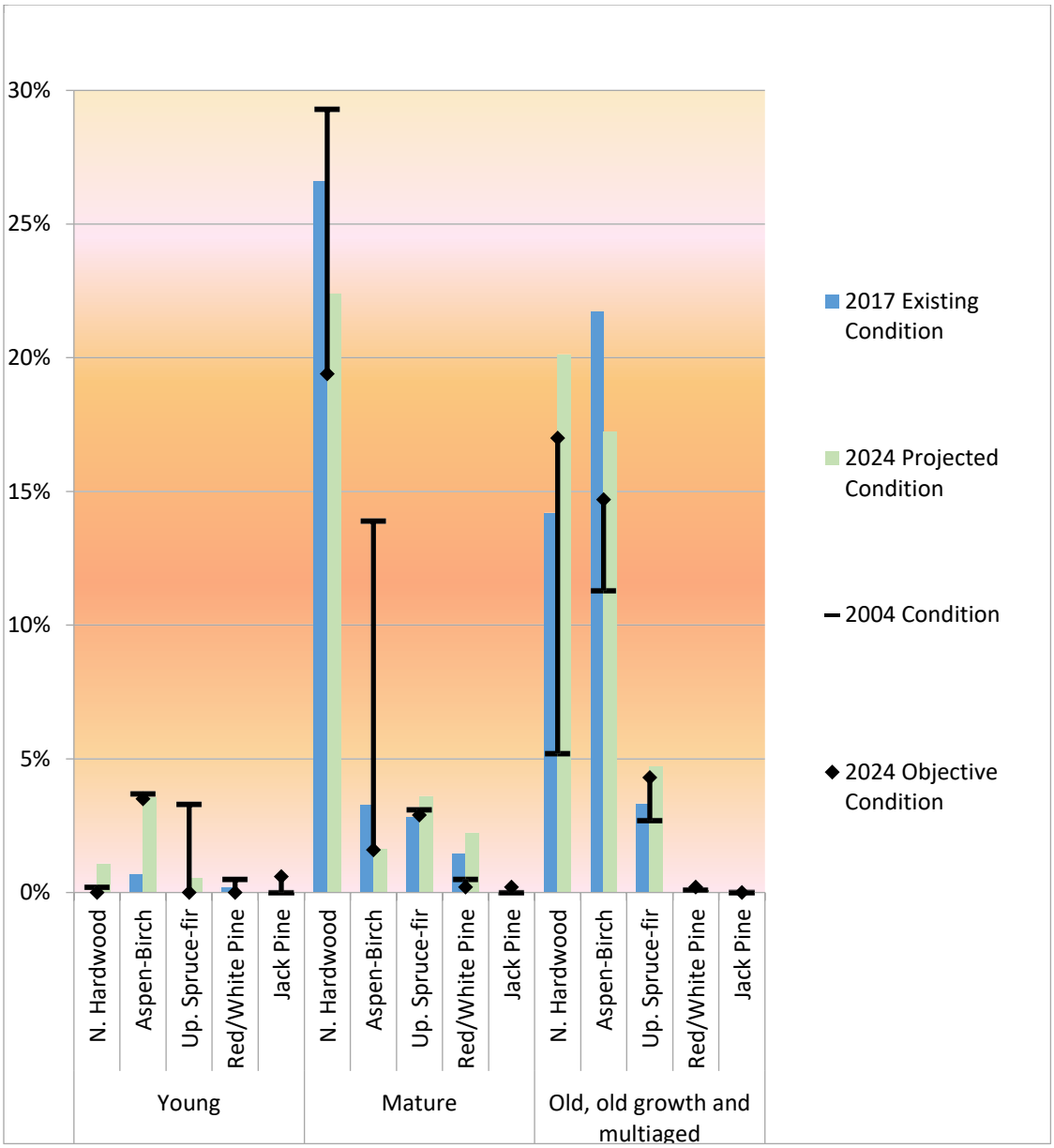


Figure 5.13-22. Progress towards objectives for management indicator habitat in the Sugar Maple LE: Decade 2

Lowland Conifer (LLC) Landscape Ecosystem

Attainment of first decade objectives 2004-2014 – MIH

Movement towards second decade and long-term objectives 2014-2024 – MIH

Table 5.13-12. Achievement of first decade and progress towards second decade objective trends for the percent of lowland black spruce tamarack forest indicator habitat in the LLC LE, compared to 2004*

Age group	Dec 1 Objective	2014 Actual	Dec 2 Objective	2017 Actual
Young	+	-	+	-
Mature	-	m	-	m
Old/multi-aged	+	+	+	+

*Gray cells show MIH trends that met Forest Plan Objectives for Decade 1 and that are projected in 2024 to be on track for achieving Forest Plan Objectives for Decade 2 (associated data is in Monitoring and Evaluation Report project file)

The LLC LE did not achieve desired habitat trends for young and mature lowland black spruce tamarack forest habitat at the end of the first decade.

The Forest projects achieving the desired trends in the indicator habitat groups for all LLC LEs combined for the second decade.

5.13.2 Vegetation Spatial Pattern Objectives

Vegetation spatial patterns (patches) are the diversity and arrangement of forest vegetation across the landscape. In particular, they refer to the size of forest disturbance and patches of forest in similar age and condition (young and mature/older forest patches). Monitoring vegetation spatial pattern objectives is important because they are Forest-wide objectives and one of the foundations of the vegetation management direction in the Forest Plan. Forest staff monitor and evaluate vegetation spatial pattern objectives four ways in this report:

1. Mature and older upland forest patches.
2. Mature and older red and white pine forest patches.
3. Mature and older lowland forest patches.
4. Temporary opening/young forest patches.

Vegetation spatial pattern objectives compliment other vegetation management direction from the Forest Plan and apply to National Forest System lands only. Vegetation objectives set the direction for changes the national forest will strive to make within the short-term (two decades) to move vegetation towards the long-term desired condition. This information is also important for interdisciplinary teams as they plan, analyze, and implement vegetation management projects on the ground.

5.13.2.1 Vegetation Spatial Pattern Monitoring Questions:

The following question is from the Forest Plan matrix in chapter 4

- To what extent are forest management, natural disturbances, and subsequent recovery restoring vegetation spatial patterns and moving conditions toward both short-term (1-20 years) and long-term (100-year) objectives at LE, spatial zone, management area, and other appropriate landscape scales?

Direction related to vegetation spatial patterns (patches) is located in the Forest Plan pages 2-22 through 2-27. Appendix *Veg-C Spatial Pattern Indicators and Drivers* contains a complete list of Forest Plan direction drivers and indicators used to evaluate the drivers, question, and methods used. This monitoring question and drivers are important for helping us track management of the

spatial patterns (patches) for young and older forest and move these components towards the long-term desired condition. Interdisciplinary teams use this information when determining the purpose and need for vegetation management activities; for conducting environmental planning and analysis; and for implementing vegetation management projects. It is also critical information for Teams as they plan and analyze vegetation management projects to implement the Forest Plan.

In general, the Forest measures forest spatial patterns in the following ways and chose these because they provide a direct comparison with Forest Plan objectives, standards and guidelines:

1. Mature and older upland forest patch objectives - acres and number of mature and older upland forest in patch sizes 300 acres and greater, 1,000 acres and greater, and 10,000 acres and greater (MIH13); and the total acres of interior habitat provided in mature and older upland forest patches (MIH 12).
2. Mature and older red and white pine forest patch objectives - acres and number of mature and older red and white pine forest in patch sizes 100 acres and greater, and 300 acres and greater (MIH 13).
3. Mature and older lowland forest patch objectives - acres and number of mature and older lowland forest in patch sizes 300 acres and greater (MIH13); and the total acres of interior habitat provided in mature and older lowland forest patches (MIH 12).
4. Temporary opening (young forest patch) objectives - acres and number of temporary openings (young forest) created through management activities; and the total acres miles per square mile of management induced edge habitat (MIH 11).

This monitoring and evaluation effort is conducted at the Forest and patch zone scales. Monitoring and evaluation of all vegetation spatial pattern objectives utilizes data extracted from the Superior National Forest FS VEG and FS VEG spatial databases for the years 2017 and 2024. The Forest compares data to Forest Plan spatial objectives, standards, and guidelines for the four forest types listed above to evaluate the current condition of forest spatial patterns using 2017 data, and uses 2024 data to forecast where the Forest will be at the end of the second decade for vegetation management efforts. At the time of publication, the Superior National Forest is working with Minnesota LiDAR imagery and other remote sensing data to better assess current condition of upland mature forest patches. The Superior anticipates the data and their associated products will be ready for use sometime in 2019 and will inform answers to the monitoring questions. Future monitoring and evaluation reports will incorporate this data in addressing questions related forest spatial patterns.

Results and Analysis – Spatial Patterns

Figures below display the measured changes in forest spatial patterns from the beginning of the first decade (2004) to the end of the first decade (2014), and compare them to the objectives, standards, and guidelines stated in the Forest Plan. Refer to Appendix *Veg-D Vegetation Spatial Patterns Data* for data associate with this section. Second decade projections are also included. Results are grouped by spatial zone were appropriate, however some general trends were observed across the Forest:

To what extent are forest management, natural disturbance, and subsequent recovery activities restoring vegetation spatial patterns and moving conditions towards short-term and long-term Forest Plan objectives?

Large Mature and Older Upland Forest Patches

- **In patch zone 1** the number and acreage of mature and older mature forest patches greater than or equal to 300 acres, and greater than or equal to 1,000 acres were below the Forest Plan minimum in the first decade. However, these trends are projected to recover and rise above Forest Plan minimums in the second decade.

- **In patch zone 2** the number of greater than or equal to10,000 acres and greater than or equal to1,000 acre patches has been maintained at Forest Plan minimum levels and is projected to continue in the second decade. Acreage of greater than or equal to 10,000 acres and greater than or equal to300-acre patches varied and remained above Forest Plan minimums in decade 1. These are also projected to remain above minimums in the second decade. Finally, he number of greater than or equal to 300 acres patches dipped below 2004 levels during the first decade (inconsistent with Forest Plan direction); however, the number of these patches has recovered in the second decade.

- **In patch zone 3** Forest Plan implementation was expected to decrease both the acres and number of large mature upland patches greater than or equal to300 acres in size in spatial zone 3. However, monitoring determined that while the numbers decreased; the acres increased indicating fewer patches on the landscape overall but with larger patch sizes of the remaining patches.

- General trends in large, mature, upland forest patches Forest wide:
    - **The size of mature and older upland forest patches is increasing.** Forest wide, the total number of greater than or equal 300-acre mature and older forest patches is decreasing. However, the acreage of greater than or equal to 300 acre patches is increasing indicating that overall patch size may be increasing. Project activities may fragment these 1,000-acre patches.
    - **Mature and older upland forest patches are becoming more pine dominated.** Red and white pine patches make up a greater percentage of the greater than or equal to 300-acre mature and older upland forest patches both in number and acreage (exceeding Forest Plan minimums for red and white pine patches). In 2004, greater than or equal to 300acre mature red and white pine patches accounted for 1.6 percent of the acreage and 2.7 percent of the number of all upland greater than or equal to 300-acre patches. In 2017, red and white pine patches make up 3.2 percent of the acres and 8.8 percent of the number. The Forest estimates that by 2024, approximately 4.5 percent of the acres and 11.2 percent of the number will consist of all mature upland patches greater than or equal to 300-acres in size.
    - **Interior upland forest habitat is increasing across the forest in all spatial zones.**

Large Mature and Older Lowland Forest Patches

- The Forest is maintaining the number and acreage of greater than or equal to 300-acre lowland patches and shows a slight increase consistent with Forest Plan direction.

- Interior forest provided by lowland forest patches has remained relatively stable in all spatial patch zones since 2010; this is consistent with Forest Plan direction.

Temporary Openings (young forest patches)

- Forest management has met Forest Plan direction by consistently creating a variety of young forest patches.
- In general, Forest management has fallen short of direction to increase the average size of young forest patches and decrease management inducted edge density in the uplands.

Large Mature and Older Upland Forest Patches

Spatial Zone 1

Forest Plan direction for large mature and older upland patches in spatial zone 1 is to maintain a minimum of eight patches greater than or equal to 1,000 acres in size (G-VG-5) and a minimum of 44,700 acres in patches of greater than or equal to 300-acres in size (S-VG-6). In addition, an objective is to maintain or increase the acres and number of greater than or equal to 300-acre patches (O-VG-23).

Figure 5.13-23. Number of greater than or equal to 1,000-acre mature and older upland forest patches in spatial zone 1

The number of large mature and older upland patches greater than or equal to 1,000 acres in spatial zone 1 has fluctuated over the past 13 years of Forest Plan implementation from five, up to nine (figure 5.13-23). The first decade (2014) ended with seven mature and older upland forest patches in zone 1or below the Plan's minimum level of eight patches. The Forest is maintaining seven large patches on the landscape currently. Ten mature and older upland patches greater than or equal to 1,000 acres in spatial zone 1 are projected by the end of the second decade (2024) to rise above the Forest Plan minimum.

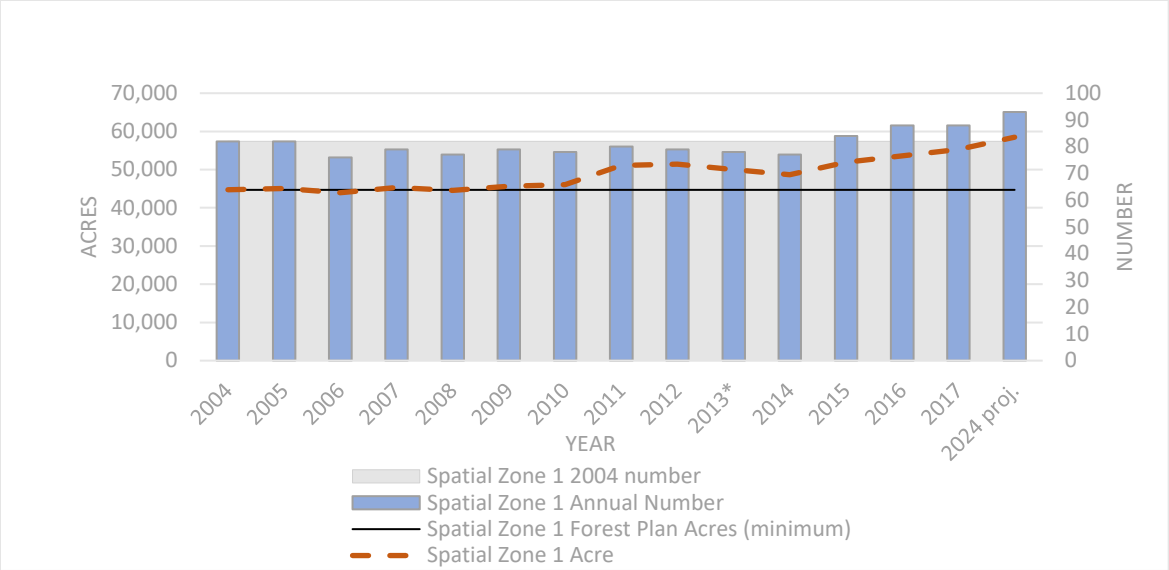


Figure 5.13-24. Acres and number of greater than or equal to 300-acre mature and older upland forest patches in spatial zone 1

The acres of large mature and older upland patches greater than or equal to 300 acres in spatial zone 1 showed a slow increase over the past 13 years (figure 5.13-24). During the first decade, acres of greater than or equal to 300-acre upland mature patches hovered near or below Forest Plan minimum levels of 44,700 acres and ended the decade with 48,648 acres of patches greater than or equal to 300 acres in size (3,948 acres above the Forest Plan minimum). Trends for the second decade show a continual rise in the acres of large mature and older upland patches greater than or equal to 300 acres in spatial zone 1, with 55,304 acres in 2017, and 58,488 acres projected at the end of the decade (2024). This is 13,788 acres above the Forest Plan minimum and is constant with the Plan's objective to maintain or increase the acres of greater than or equal to300-acre patches in this spatial zone. The number of large mature and older upland patches greater than or equal to 300 acres dipped below 82 patches (2004 number) during the first decade of Forest Plan implementation to a low of 76 patches in 2007. This is inconsistent with the Forest Plan objective to maintain or increase the number of these patches (figure 5.13-24). However, during this second decade the number of greater than or equal to 300-acre patches has recovered and begun to increase. In 2017, there are 88 patches, and by 2024, the Forest estimates around 93 patches.

Spatial Zone 2

Forest Plan direction for large mature and older upland patches in spatial zone 2 is to maintain a minimum of one patch greater than or equal to 10,000 acres in size (G-VG-4), and a minimum of 14 patches greater than or equal to 1,000 acres in size (G-VG-6). In addition, a minimum of 11,700 acres of mature and older upland forest should be in patches of greater than or equal to 10,000 in size (S-VG-5), and 54,400 acres in patches of greater than or equal to 300 acres (S-VG-7). Lastly, a Forest Plan objective is to maintain or increase the acres and number of greater than or equal to 300-acre patches (O-VG-23).

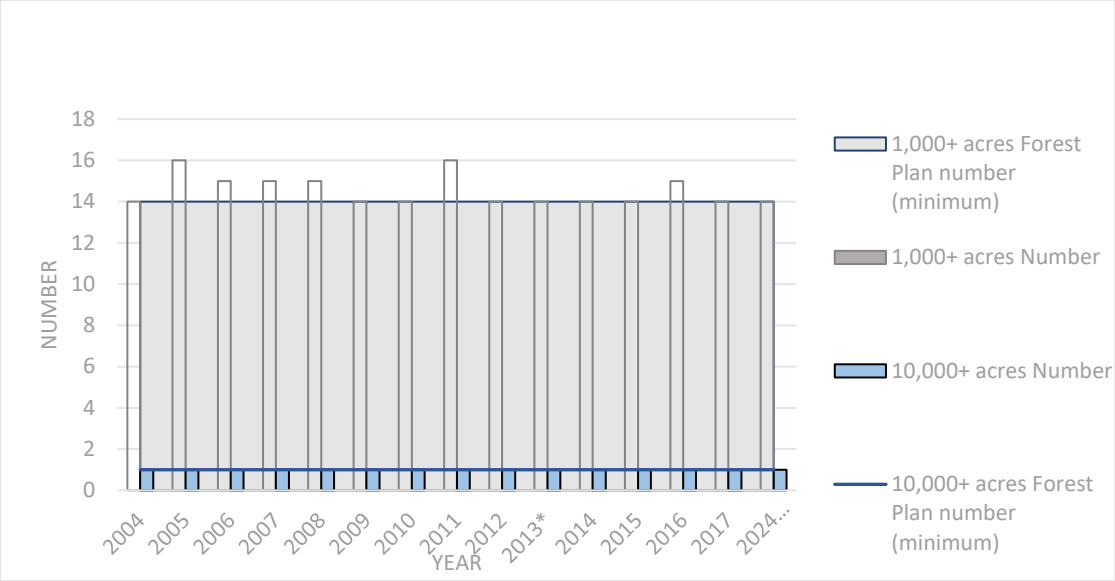


Figure 5.13-25. Number of 1,000-plus acre and 10,000-plus acre mature and older upland forest patches in spatial zone 2

The number of large mature and older upland patches in spatial zone 2 have consistently remained at or slightly above Forest Plan minimum levels (figure 5.13-25). Over the course of the past 13 years of Plan implementation, one patch greater or equal to 10,000 acres has been maintain and is projected to persist into the end of the second decade (2024). The number of greater or equal to 1,000 acre patches have fluctuated between 14 (Forest Plan minimum) and up to 16. Current (2017) and projected levels at the end of the second decade (2024) is at the minimum of 14 large mature and older upland patches in spatial zone 2.

Over the course of the past 13 years of the Plan's implementation, acres of mature and older upland forest patches have varied and remained above Forest Plan minimums in both greater or equal to 300 and greater or equal to 10,000-acre size patches.

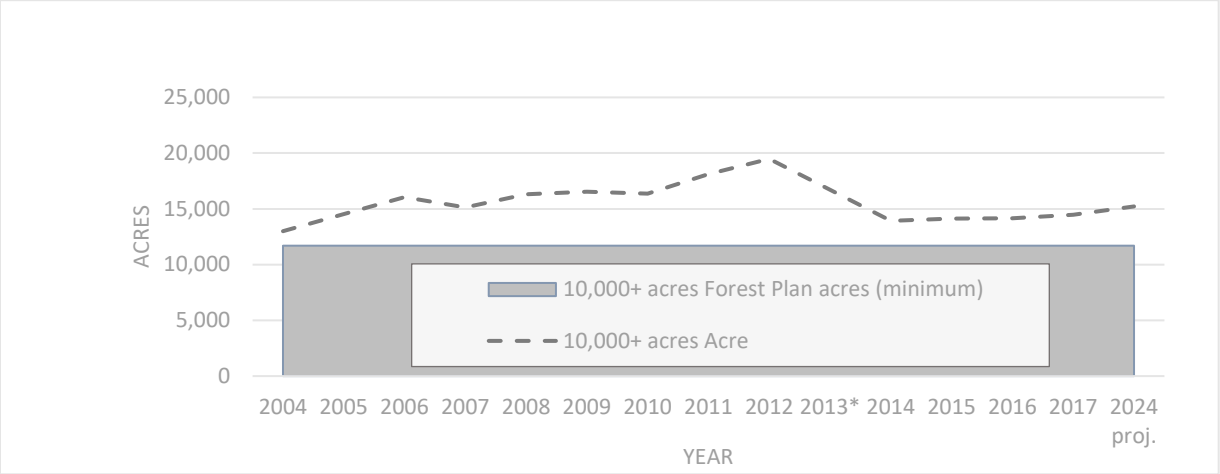


Figure 5.13-26. Acres of mature and older upland forest patches 10,000-plus acres in spatial zone 2

At the end of the first decade (2014), there was 13,942 acres in patches greater than or equal to 10,000 acres, above the Plan's standard minimum by 2,242 acres (figure 5.13-26). In the second decade, this increase will continue going from 14,461 acres in 2017 to a projected 15,216 acres by 2024, above the Plan's standard minimum by 2,761 acres (2017) and 3,516 acres (2024).

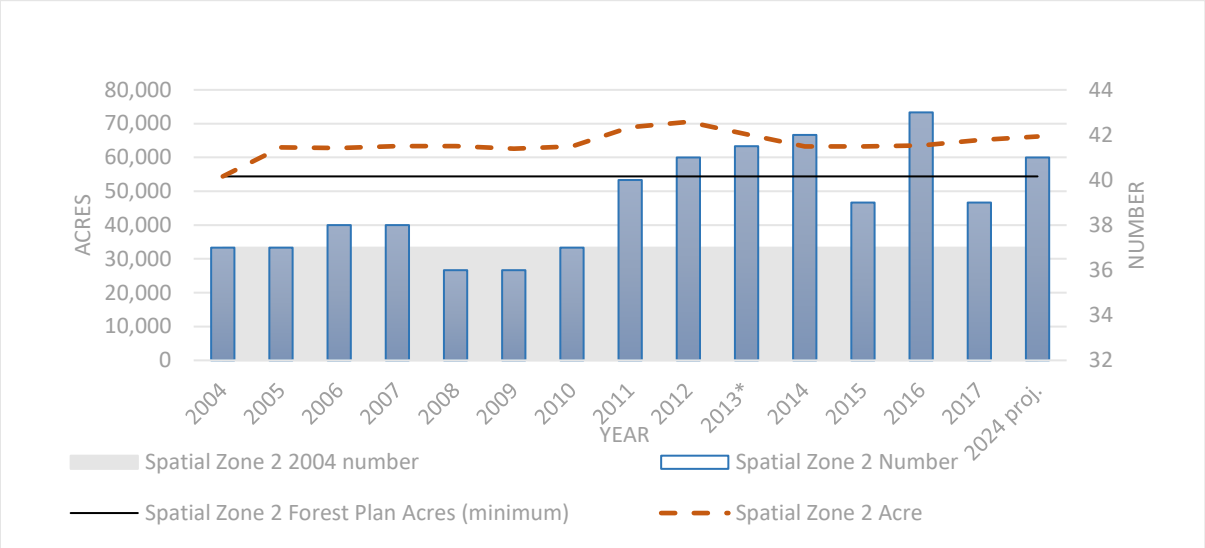


Figure 5.13-27. Acres and number of greater than or equal to 300-acre mature and older upland forest patches in spatial zone 2

At the end of the first decade (2014), there were 63,260 acres of mature and older upland forest in patches greater than or equal to 300 acres; above the Plan's standard minimum by 8,860 acres (figure 5.13-27). Mature and older upland forest in greater than or equal to 300 acre patches is projected continue to increase from 65,153 acres in 2017 to 66,226 acres by 2024, above the Plan's minimum by 10,753 acres and 11,826 acres correspondingly.

The number of large mature and older upland patches greater than or equal to 300 acres dipped below 2004 number of 37 patches during the first decade of Plan's implementation to a low of 36 patches in 2008 and 2009. This is inconsistent with the Plan's objective to maintain or increase the number of these patches. However, during this second decade the number of greater than or equal to 300 patches has recovered and increased. In 2017, there are 39 patches and by 2024, the Forest anticipates around 41.

Spatial Zone 3

Forest Plan direction for large mature and older upland patches in spatial zone 3 is to strive to minimize the decrease in acres and number of patches greater than or equal to 300 acres in size (O-VG-25).

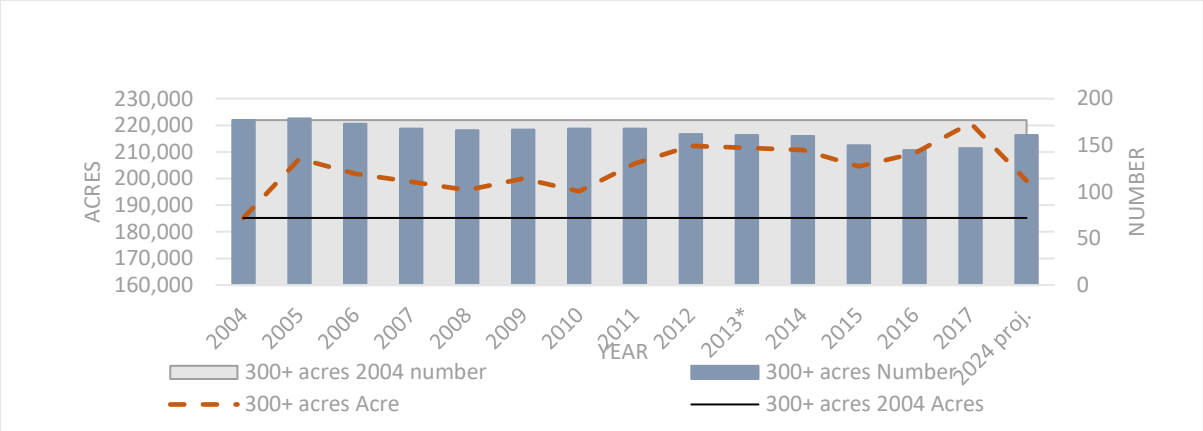


Figure 5.13-28. Acres and number of greater than or equal to 300-acre mature and older upland forest patches in spatial zone 3

The acres of large mature and older upland patches greater than or equal to 300 acres in spatial zone 3 show an increase over the past 13 years (figure 5.13-28). The first decade ended with more acres in the patch size, with 185,200 acres in 2004 and 210,756 acres in 2014. This upward trend has continued with 220,844 acres in 2017 and 199,203 acres projected in 2024. The number of large mature and older upland patches greater than or equal to 300 acres dipped below 2004 number of 177 patches during the first decade of Forest Plan implementation and has remained below, for a low of 145 patches in 2015. In 2017, there are 147 patches and by 2024, the Forest anticipates around 161.

Forest Plan implementation expected to decrease both the acres and number of large mature upland patches greater than or equal to 300 acres in size in spatial zone 3. Monitoring disclosed that the number decreased; however, the acres increased indicating that although there are fewer patches, they have increased in size.

Interior Forest Conditions

Forest Plan objectives (O-VG-22 and O-VG-25) are to maintain or increase the amount of interior forest habitat in spatial zones 1 and 2; and to strive to minimize the decrease in spatial zone 3 in a variety of upland vegetation communities.

Forest-wide monitoring data is only available since 2010 for interior forest habitat. In spatial zone 1, upland interior forest habitat dipped below the 2004 condition of 30,762 acres to 27,815 acres. This is inconsistent with Plan direction to maintain or increase (figure 5.13-28). However, by 2015 the amount of upland interior forest had recovered in zone 1. Currently (2017) in spatial zone 1, there are 32,762 acres and by 2024 there is projected to be 32,114 acres of upland interior forest habitat; above 2004 levels by 1,340 acres and 1,352 acres respectively. In spatial zone 2, since 2010, the Forest has met Forest Plan direction by maintaining the acres of upland interior forest above the 2004 condition of 31,313 acres.

Currently (2017) in spatial zone 2, there are 35,095 acres of interior forest habitat. By 2024, there is projected to be 35,302 acres of interior upland forest habitat; remaining above the 2004 condition by 3,782 acres and 3,989 acres respectively. Spatial zone 3 has shown similar trends to zone 2 with the Forest maintaining upland interior forest habitat above the 2004 condition of 79,283 acres. At the time of Forest Plan revision, there was predicted a decrease in upland interior forest habitat in zone 3 from Forest Plan implementation. This has not occurred.

Currently (2017) in zone 3, there are 92,340 acres and by 2024, there is projected to be 87,357 acres of interior upland forest habitat; remaining above 2004 condition by 13,057 acres and 8,074 acres respectively.

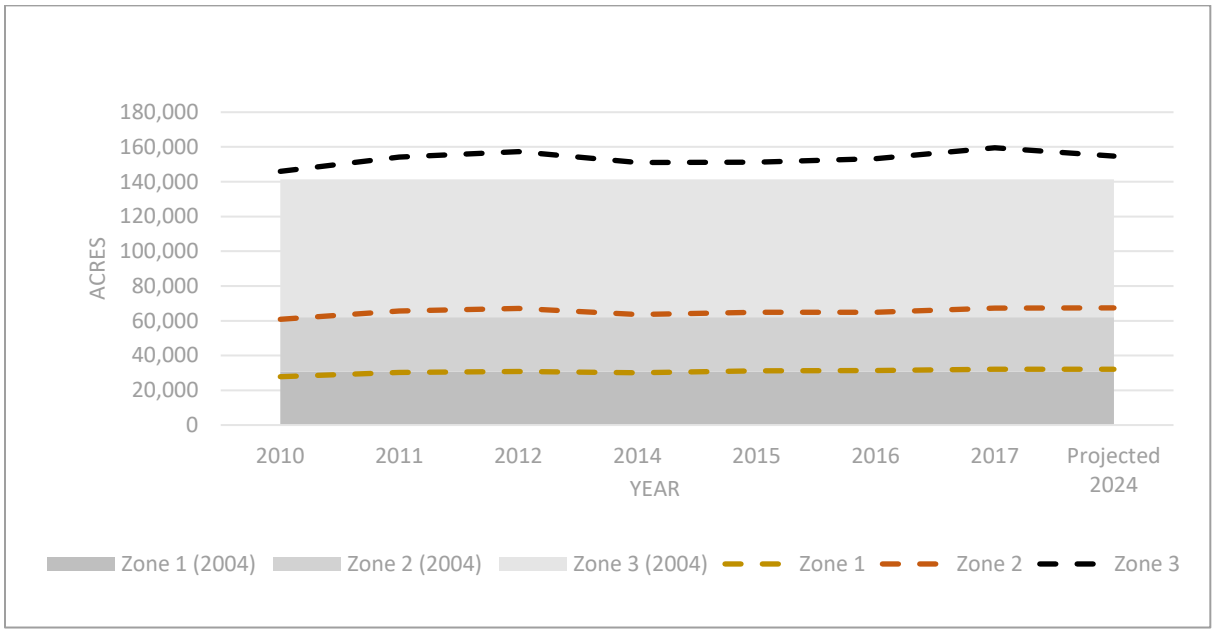


Figure 5.13-29. Acres of interior forest habitat in upland forests by patch zone

Mature and Older Red and White Pine Forest Patches

Forest Plan standards (S-VG-2 and S-VG 3) are to maintain a minimum of 4,700 acres of mature and older red and white pine forest types in patches greater than or equal to 300 acres, and a minimum of 17,300 acres in patches greater than or equal to 100 acres.

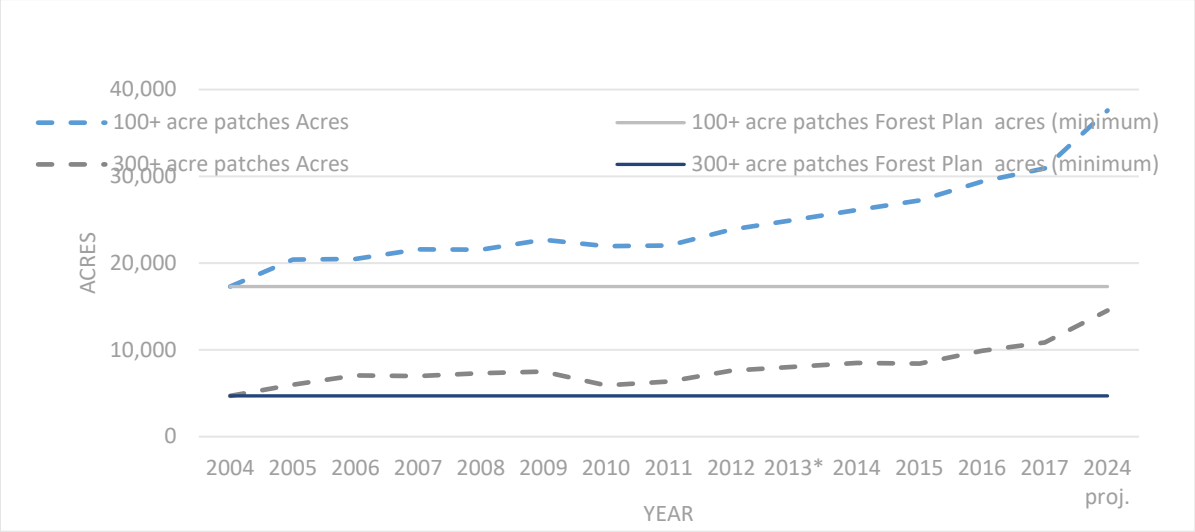


Figure 5.13-30. Acres of mature and older red and white pine forest patches

For 13 years of Forest Plan implementation, the acres of mature and older red and white pine forest patches have steadily increased in both greater than or equal to 100 and greater than or equal to 300-acre size patches (figure 5.13-30). At the end of the first decade (2014), there were 26,112 acres of mature and older red and white pine forest in patches greater than or equal to 100 acres, and 8,497 acres in patches greater than or equal to 300 acres; surpassing the Plan's standard minimum by 8,812 acres and 3,797 acres respectively. This increase has and is projected to continue. Mature and older red and white pine forest in greater than or equal to100-acre patches are projected to go from 30,898 acres in 2017 to 37,590 acres by 2024, surpassing the Plan's minimum of 17,300 acres by 13,598 acres and 20,290 acres correspondingly. Three-hundred acre and greater patches show a similar pattern going from 10,863 acres in 2017 to 14,539 acres by 2024, exceeding the Plan's standard minimum of 4,700 acres by 6,163 acres and 9,839 acres.

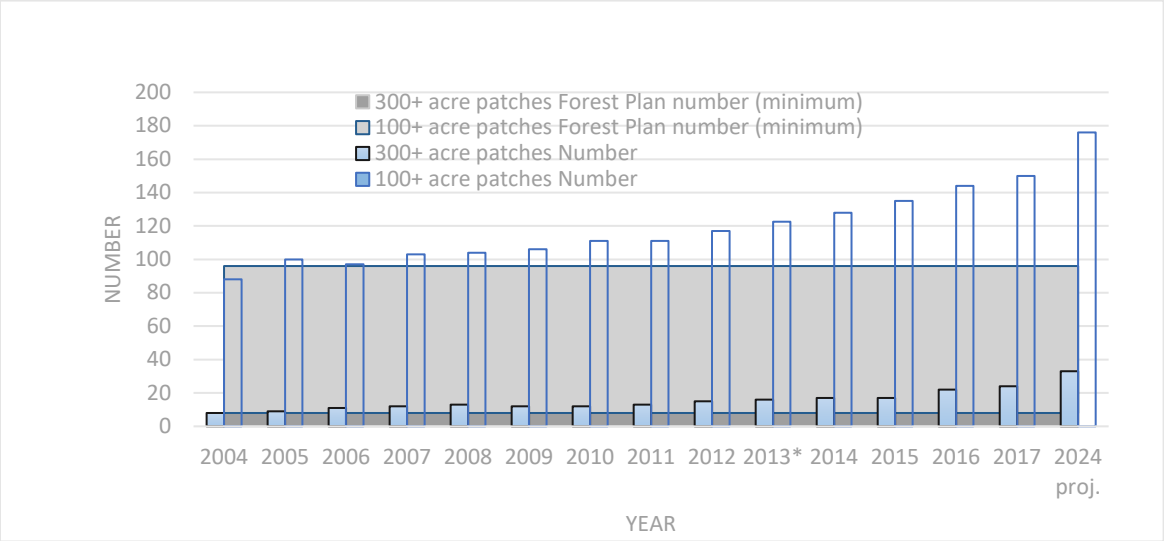


Figure 5.13-31. Number of mature and older red and white pine forest patches

Forest Plan guidelines (G-VG-1 and G-VG-2) are to maintain a minimum of 88 patches of mature and older red and white pine forest types in patches greater than or equal to100 acres in size. In addition, the Plan states to work to maintain the number of patches greater than or equal to 300 acres above eight.

The number of patches have also increased, similar to the trend in acres of mature and older red and white pine forest patches (figure 5.13-31) At the end of the first decade (2014), there were 128 patches of mature and older red and white pine forest greater than or equal to100 acres in size. In 2017, there were 150, and by the end of the second decade, the Forest anticipates around 176. This surpasses the Plan's minimum number of 88 one-hundred acre and greater mature and older red and white pine patches by 40, 62 and 88 patches respectively. Mature and older red and white pine forest in patches greater than or equal to 300-acres numbered 17 at the end of the first decade (2014), whereas in 2017 there were 24 and by the end of the second decade (2024) there are projected to be 33. This surpasses the Plan's minimum number of eight, 300-acre and greater mature and older red and white pine patches by nine, 16 and 25 respectively.

Mature and Older Lowland Forest Patches

Forest Plan direction for large mature and older lowland patches includes maintaining a representative array of large patches (greater than or equal to 300 acres) across the Forest (O-VG-19). In addition, Forest Plan objectives (O-VG-22 and O-VG-25) are to maintain or increase the amount of interior forest habitat in spatial zones 1 and 2; and to strive to minimize the decrease in spatial zone 3 in a variety of lowland vegetation communities.

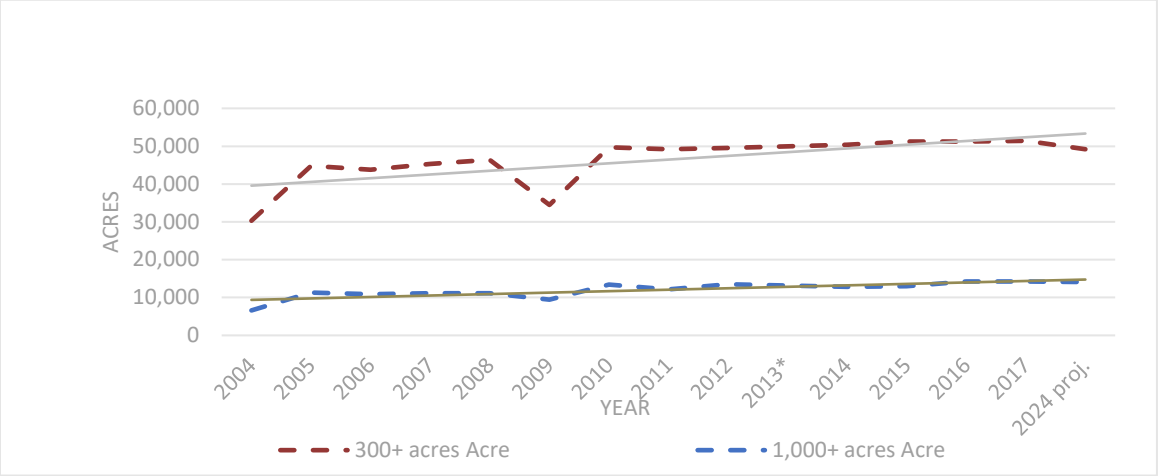


Figure 5.13-32. Acres of mature and older lowland forest patches

Over the past 13 years, the Forest has increased the acres of large mature and older lowland patches greater than or equal to 300 acres (figure 5.13-32). The first decade ended with more acres in patches greater than or equal to 300 acres size, with 30,300 acres in 2004 and 50,384 acres in 2014. This upward trend has continued with 51,421 acres in 2017, with the Forest expecting a slight dip with 49,192 acres for 2024. Lowland mature patches greater than or equal to 1,000 acres show a similar though lower trend.

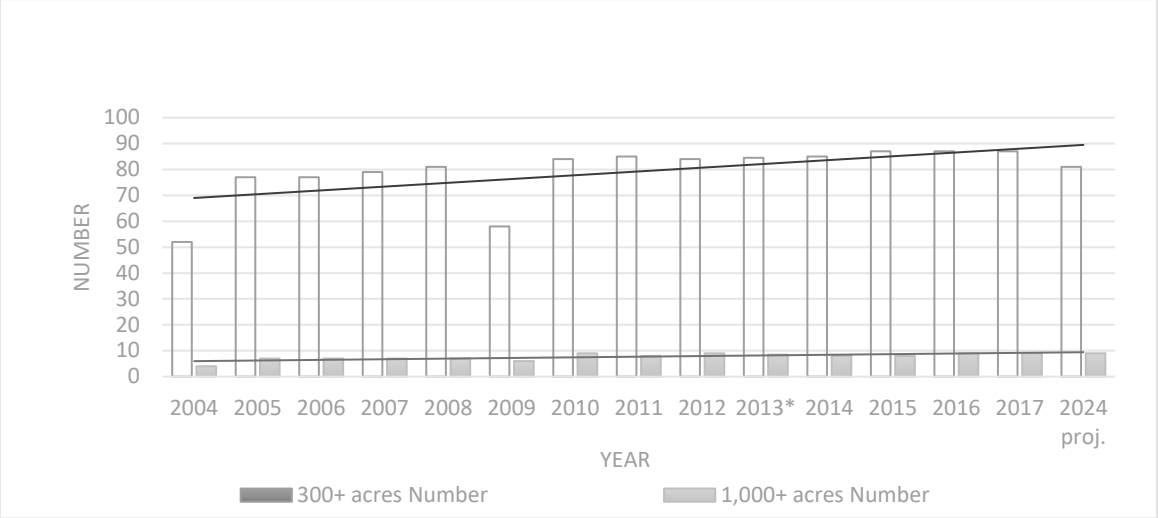


Figure 5.13-33. Number of mature and older lowland forest patches

The past 13 years the Forest has also increased the number of large mature and older lowland patches greater or equal to 300 acres (figure 5.13-33). The first decade ended with more patches

greater than or equal to 300-acres size, with 52 in 2004 and 85 in 2014. This upward trend has continued with 87 in 2017 and a slight dip with 81 projected in 2024. Lowland mature patches greater than or equal to 1,000-acre show a similar though lower trend.

The amount of interior forest habitat provided by mature and older lowland forest patches has remained relatively stable in all spatial patch zones, since monitoring began in 2010. This is consistent with Forest Plan direction to maintain and increase in zones 1 and 2 and strive to minimize the decrease in zone 3 (figure 5.13-34). In spatial zone 1, the amount of lowland interior forest habitat has been as low as 22,080 acres in 2010 and as high as 23,086 in 2014. Patch zone 2 has fluctuated from a low of 3,941 acres in 2010 to a high of 4,665 acres in 2017. Lowland interior forest habitat in spatial zone 3 has fluctuated from a low of 8,666 acres in 2012 to a high of 9,014 acres in 2016.

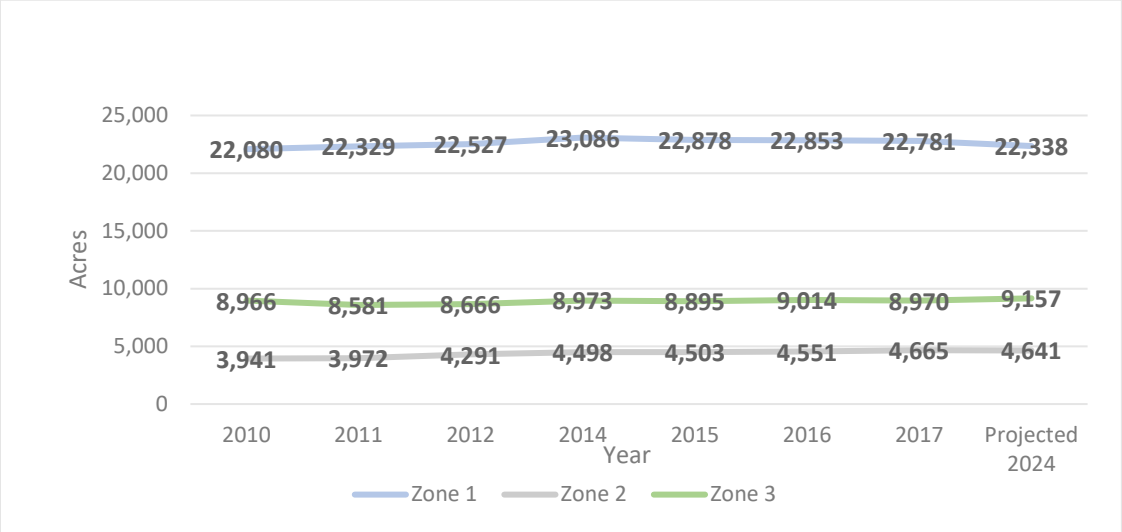


Figure 5.13-34. Acres of interior forest habitat in lowland forests by patch zone

Temporary Openings (Young Forest)

Forest Plan direction for temporary openings (young forest) patches are to create large patch temporary forest openings up to 1,000 acres through management activities (G-VG-1). In addition, Forest Plan objectives (O-VG-21 and O-WL-35) are to increase the average size of temporary forest openings and to reduce the amount of forest edge created through vegetation management activities, while retaining a range of small patches and edge habitat.

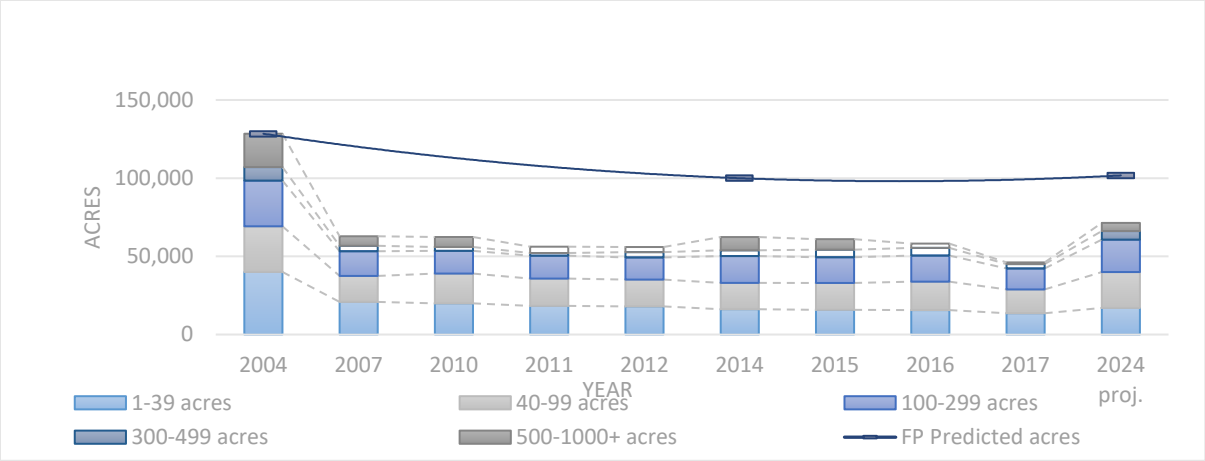


Figure 5.13-35. Temporary openings (young forest) patches by patch size groups in upland forest

With implementation of the Forest Plan, the Forest Service predicted a decrease and then a leveling out of young forest on the landscape in the FEIS: This forecast occurred. During the first three years of Forest Plan implementation there was a 51percent reduction in the acres of young upland forest between 2004 (128,408 acres) to 2007 (62,837 acres) (figure 5.13-35). Since 2007, the Forest has conducted monitoring and this has been reduced substantially with 46,125 total acres of young forest currently (2017) and 71,377 acres projected in 2024. As figure 5.13-34 shows, the total amount of young forest has consistently been below the model predicted level by the FEIS (not Forest Plan direction). This indicates that all Plan implementation has not occurred and is consistent with findings in the landscape ecosystem section of the vegetation chapter of this report. Management of temporary openings of young upland forest aligns with Forest Plan direction, creating a variety of young forest patches up to 1,000 acres, with most patches less than 100 acre in size. In addition, there is room to increase the acres and size of young forest patches to come closer to Forest Plan predicted levels.

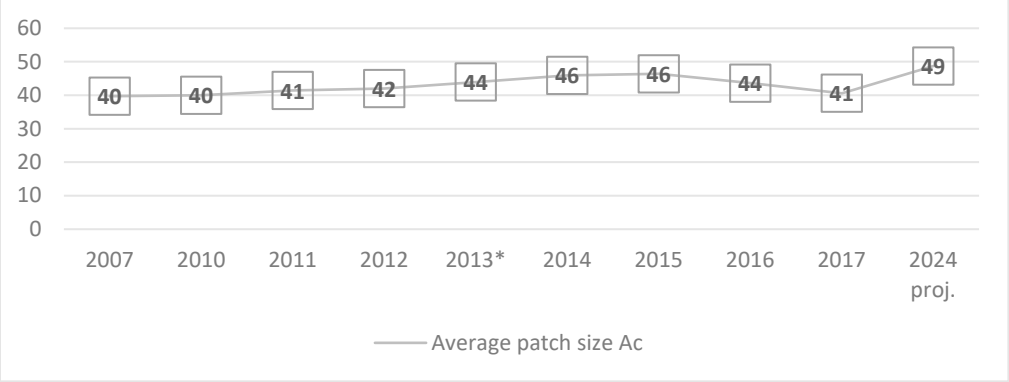


Figure 5.13-36. Average young forest patch size (acres) in upland forest

The average size of temporary forest openings has not increased as directed by the Forest Plan (figure 5.13-36). In 2004, the average young forest patch size was 46 acres; the patch size actually decreased to a low of 40 acres in 2010. Currently (2017), the average young forest patch size is 41 acres; however, by 2024 the average is projected to increase to 49 acres in size.

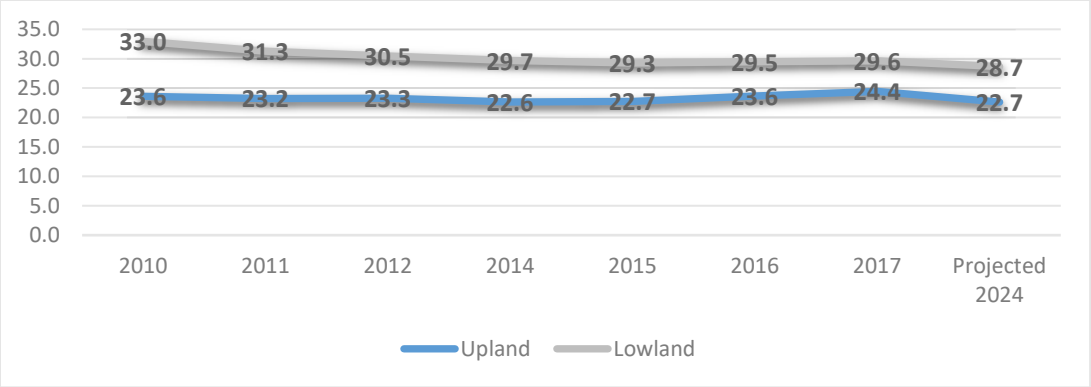


Figure 5.13-37. Management-induced edge density in upland and lowland forest (mi/mi2)

Similarly, Forest management has fallen short of the Forest Plan objective to decrease management-induced edge density in upland forest (figure 5.13-37). This relates to continuing to manage smaller patch sizes on average. In lowland forests, the Forest has reduced edge density.

5.13.3 White Pine -Management Indicator Species

5.13.3.1 Management Indictor Species/Focal Species – White Pine Monitoring Question:

The following question is from the Forest Plan matrix in chapter 4

- To what extent is forest management moving toward short term (10-20 years) and long-term (100-year) objectives for habitat conditions for management indicator species/focal species – white pine?

Drivers

Objective. O-WL-32. Increase amount of white pine to amounts more representative of native plant communities by planting or naturally regenerating white pine trees in white pine forest types and in other upland deciduous, mixed, and conifer forest types. This objective matches white pine objectives shown in the landscape ecosystem (LE) objectives section.

Objective. O-WL-33. Manage to improve white pine survival on planted sites and as many naturally regenerating sites as possible.

36 CFR 219.12(a)(5)(iii) The status of focal species to assess the ecological conditions required under CFR 219.9

Indicators – The unit of measure are:

1) White pine forest type acres and percent by LE. This measure compares against decade 1 and decade 2 objectives for white pine percent (Forest Plan pp. 255-273).
2) 2) The number of white pine seedlings planted. The monitoring question, Forest Plan objectives, units of measure and units of comparison were chosen because white pine is a management indicator species, as well as a focal species for which monitoring is required. In addition, the Forest Plan provides distinct objectives for increasing white pine on the Forest.

Method – The Forest conducts this monitoring effort at five of the six LE levels, as well as Forest wide. The Lowland Conifer LE was not included because there are no white pine composition objectives for that forest type in that LE. Monitoring and evaluation of white pine utilizes data extracted from the Superior National Forest FS VEG and FS VEG Spatial databases for the years 2017 and 2024 and compares the data to Forest Plan forest type objectives for white pine at the landscape ecosystem level. The 2017 data were used to evaluate the current condition of the forest spatial patterns; while, the 2024 data forecasts where the Forest will be at the end of the second decade with current and proposed vegetation management efforts.

Results

While white pine tended to meet Forest Plan decade 1 composition objectives (Vegetation Section 1 Landscape Ecosystems, Appendix Veg-A), it is projected to fall slightly short of meeting decade 2 objectives in nearly every LE. A decline in this pine species on the landscape affects the entire ecosystem from the wildlife species that depend on them for both food and shelter, along with the indirect effects they have on shade and soil acidity. To change this and increase their presence on the landscape, the Forest needs to invest more in planting, restoring, protecting from deer browse, and preparing sites these species to thrive.

Figure 5.13-38 shows the amount of white pine forest type (forested stands dominated by white pine trees). The number of acres of white pine forest type increased from 30,700 acres in 2004 to 42,594 at the end of decade 1 (2014). The Forest calculates that white pine (as a forest type) will increase again to 44,486 acres by the end of decade 2 (2024).

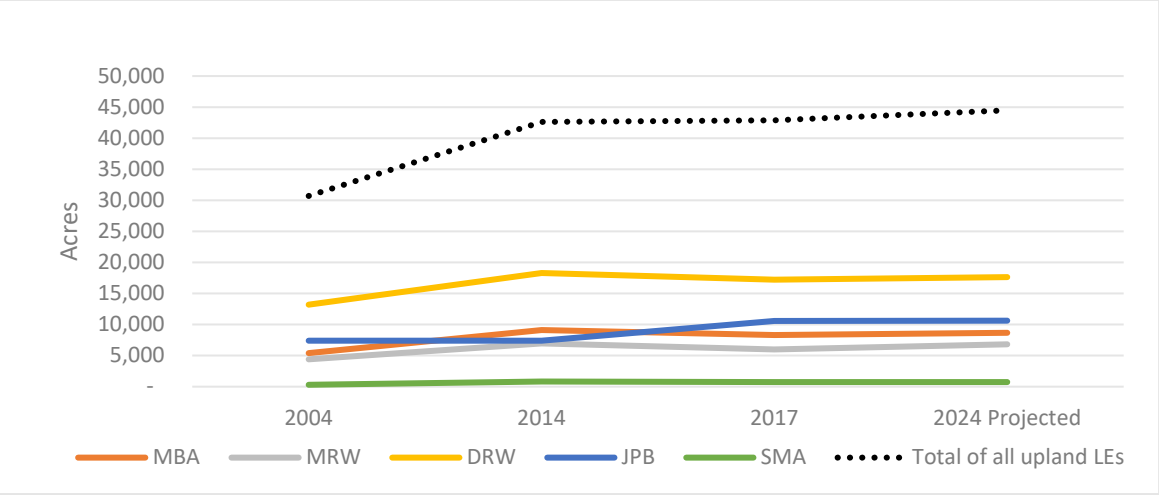


Figure 5.13-38. White pine forest type in decades 1 and 2

All upland LEs have objectives for increasing white pine. By the end of the first decade, stands typed as white pine (FT3, 30) increased by 7,000 acres, in part by the amount of white pine seedlings planted: 5,866,000. The Forest planted seedlings both as a single species to convert stands to white pine and with one or more other species to increase within-stand diversity. Emphasis on white pine over the past 13 years of Plan implementation has set the Forest on a good path for the long- terms goals for white pine forest type and within-stand diversity.

Figure 5.13-39 compares white pine forest type acres and percent by LE to decade 1 and decade 2 objectives. The percent of white pine forest type increased in all upland LEs.

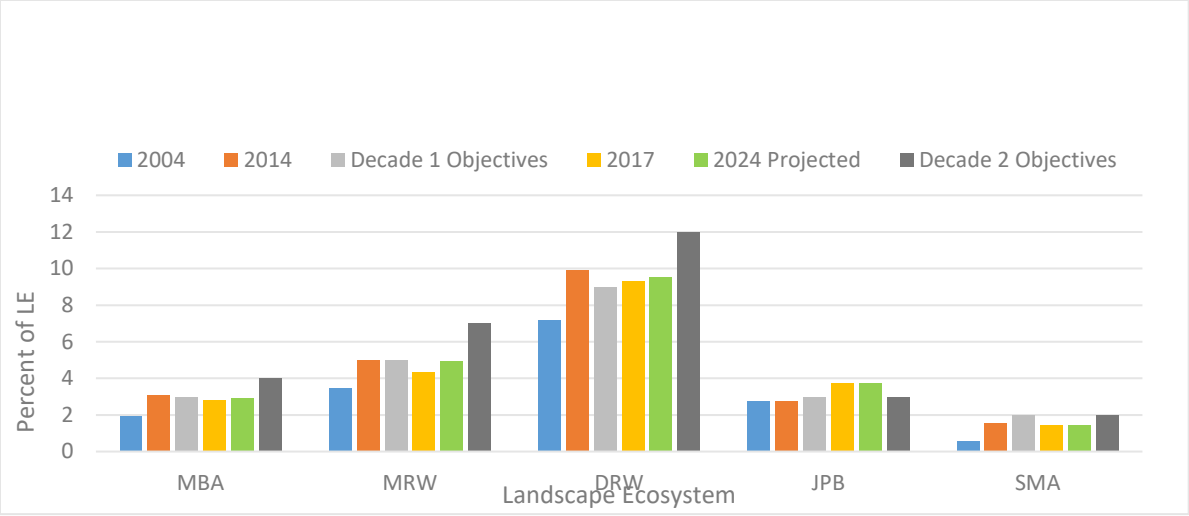


Figure 5.13-39. White pine forest type percent of LE forest wide

Analysis

These monitoring results, and the increase in white pine forest type, validates planting practices. The Superior is successfully increasing white pine on the landscape.

5.13.4 Forest Insect and Disease

Monitoring for insect and disease conditions on the Superior National Forest (SNF) is critical to anticipate and mitigate for insect and disease outbreaks. Assessing insect and disease infestations and trends is a multi-agency effort due to the extensive mixed ownership in northeastern Minnesota. For a number of years, monitoring has been a collaborative effort between the Minnesota Department of Natural Resources (MN DNR) Forest Health and Resource Assessment Units and the Forest Service, State, and Private Forestry division.

5.13.4.1 Insects and Diseases Populations Monitoring Question:

The following question is from the Forest Plan matrix in chapter 4:

Are insects and diseases populations compatible with objectives for restoring or maintaining healthy forest conditions?

Drivers

- 36 CFR 219.12 (k)(5)(iv). Destructive insects and disease organisms do not increase to potentially damaging levels following management activities.
- D-ID-3. Insects and diseases are present and fulfilling their ecosystem function. Epidemics, when they occur, do not last longer than would be expected in a healthy ecosystem.
- D-VG-5. Vegetation constantly changes through management activities and through naturally occurring disturbances and ecosystem recovery processes such as wind, fire, flooding, insects, disease, and vegetation succession. These fluctuations are within an ecologically and socially acceptable range of variability.

- O-VG-11. Retain an adequate representation of naturally disturbed forest not salvaged, burned, flooded, blowdown, or insect- or disease-killed areas. Maintain these in a variety of patch sizes and distributions on the landscape.

Indicators

- Acres of impact on the Superior NF
- Population estimates

Method – Methods include annual aerial surveys, trapping (gypsy moth and emerald ash borer), and MNDNR Forest Health Assessment reports for 2013 to 2017.

Chapters on fuels and climate change also address these questions.

Results, Analysis, and Recommendations

Table 5.13-13 lists the number of acres on the Superior NF affected by insects, diseases, and other disturbances found in aerial surveys from 2013 to 2017. The following figures and tables identify where each agent affected the Superior National Forest each year from 2013 to 2017.

Table 5.13-13. Annual aerial survey on the Superior NF. Acres affected on all ownerships within the SNF boundary

	2013	2014	2015	2016	2017
Spruce budworm	20,804	58,929	88,914	84,408	45,036
Aspen decline	20,466	6,838	11,705		
Wind/tornado		991		13,268	
Forest tent caterpillar	4,159	1,507	2,909	1,169	164
Unknown agents	32	3		197	3,247
Other agents	5,125*		3	1,257[f]	399

* Leaf roller and large aspen tortrix. [f] Largely abiotic factors

Section 5 of this chapter, on restoration needs, lists more recommendations for forest health.

Spruce Budworm (SBW)

The spruce budworm population on the Superior NF is not compatible with objectives of maintaining and restoring healthy forest conditions.

The SBW, a native insect, continues to defoliate fir and spruce in northeastern Minnesota. Minnesota has mapped the infestations a since 1954. In 2006, the population spiked Statewide during a large outbreak when the acres affected almost reached 300,000.

The amount of acres affected by SBW on the Superior NF has been consistently high for many years and up to 88,914 acres in 2015 (table 5.13-14)

Unlike other areas in the U.S. and Canada with SBW, the population in Minnesota never entirely crashes. Instead, the insect invades an adjacent area. The impacts of SBW are expected to continue moving east across northeastern Minnesota.

Multi-storied stands of balsam fir and white and black spruce, which spruce budworm favor, are widespread across the SNF. The increase in forest types dominated by fir and spruce has created more habitat for SBW (see section 1 of this chapter).

The northern superior uplands was identified as a hot spot nationally for exposure to defoliation from spruce budworm (and forest tent caterpillar) (USDA 2018b), emphasizing the need to limit conditions favorable to SBW.

Direct treatment of spruce budworm infestation continues to be limited due to the presence of the insect in mixed ownership patterns. In addition, stands with a fir component, the most susceptible, are often low volume; low-value stands and are very expensive to treat. The SNF is harvesting to treat current vegetation to lessen its future susceptibility to spruce budworm.

Eastern Dwarf Mistletoe (DMT)

The percent of lowland black spruce stand infested with dwarf mistletoe is likely not compatible with objectives for maintaining and restoring healthy forest conditions.

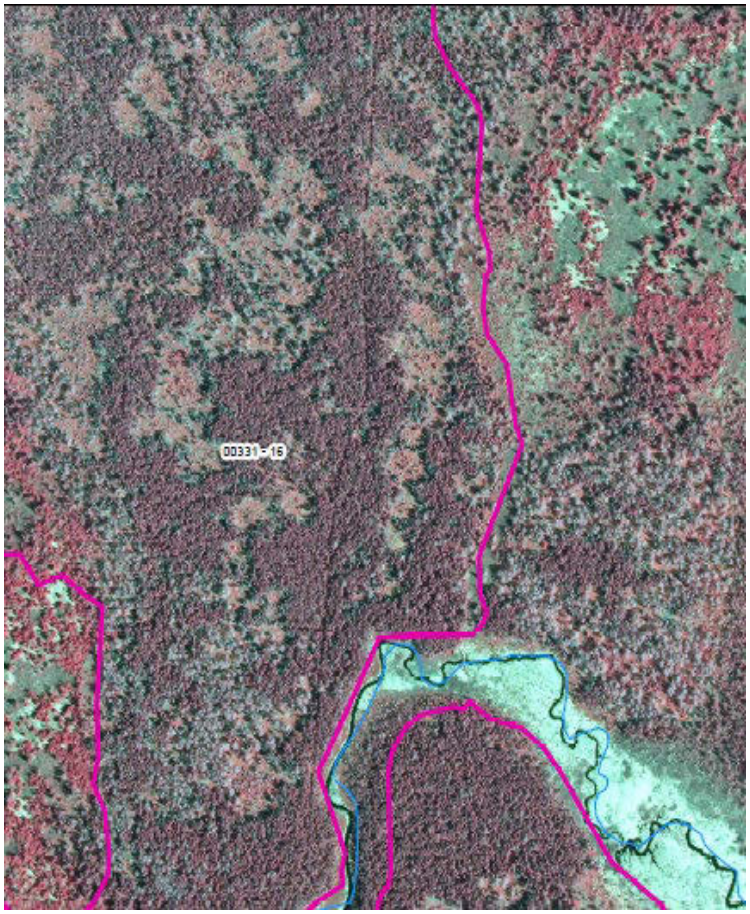


Figure 5.13-40. Infrared air photo of DMT mortality (stand number D07-C331-S016)

The DMT is a native pest and always fatal, but it takes a number of years for DMT to kill all black spruce in a stand. It is the major cause of loss in black spruce in Minnesota, in part because it kills all ages and sizes of black spruce (USDA 1977). In the distant past, wildfire controlled DMT, where in the more recent past, prescribed fire was used in lowland black spruce.

Baker et al. (2012) examined how FIA and the MN DNR identify DMT and found that both organizations underestimated the amount of infested stands. Baker found that 55 percent of black spruce stands were infested. Their findings are consistent with recent field recon on the Superior NF in lowland black spruce (Toohey, Stony, TomaInga project areas). In the Stony Project area in particular, nearly every stand surveyed by a forester or technician trained in identifying DMT was found infested to varying degrees. Identifying DMT is also possible with aerial photos (figure 5.13-40). The Superior NF has 150,000 acres of lowland black spruce.

The Superior NF has not harvested a lot of lowland black spruce. There is a need to create more young black spruce stands (see section 5.13.1.0). Treating for DMT requires cutting all ages and sizes of black spruce stems, including regeneration. The best treatment requires not leaving any reserve areas or black spruce trees, which may not be consistent with Forest Plan guidelines for leave trees, reserve areas, and riparian areas. Sometimes, black spruce in riparian areas may also need to be cut. However, it is important to treat black spruce stands this way to maintain lowland stands in a forested condition.

The following is recommended for DMT:

- Develop prescriptions for prescribed burning in lowland black spruce.
- Prioritize DMT treatment before winter operations become too difficult due to warmer winters
- Increase training for DMT identification
- Examine Forest Plan guidance for flexibility in the guidance when treating stands for insects and diseases, to allow effective treatments limiting DMT infections.

Forest Tent Caterpillar

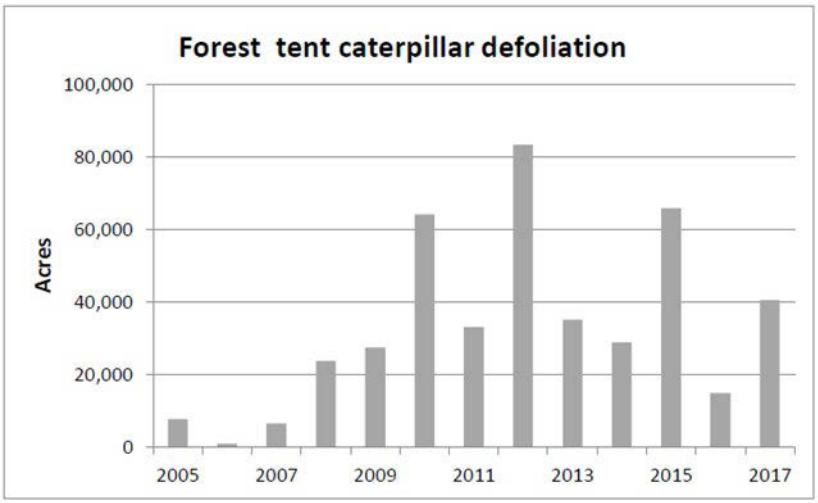


Figure 5.13-41. Forest tent caterpillar defoliation statewide from 2005 to 2017. From MN DNR Forest Health Assessment Report for 2017.

Forest tent caterpillar can lead to mortality if the same tree is defoliated two to three years in a row; however, on the Superior NF it mostly a nuance. Populations tend to spike in 10 to 16 year intervals. In 2002, forest tent caterpillars affected seven million acres. In 2012, another, smaller, spike occurred Statewide with more than 80,000 acres affected (figure 5.13-40). Minnesota could experience another peak in the next couple of years. On the Superior NF, forest tent caterpillar defoliation has decreased every year for the last five years (table 5.13-14)). However, outside of the town of Tower, there is a 7,000-acre outbreak area mapped with severe defoliation. This outbreak is adjacent to the Laurentian District.

Gypsy Moth

Gypsy moths, non-native invasive insects, were estimated to be at very high levels in 2013 (table 5.13-14) with most of the activity occurring along the North Shore (Gunflint and Tofte Ranger Districts). However, St. Louis County also had high numbers. In 2013, the Minnesota Department of Agriculture (MDA) treated approximately 58,000 acres with a mating disruptive pheromone. Treatments were largely on the Kawishiwi and Laurentian Ranger Districts in St. Louis County.

Trap catches fell sharply after the severe winter of 2013/2014. Warmer winters in the future could mean another increase in gypsy moth populations.

To reduce the amount of moths transported by people into northeastern Minnesota, the State of Minnesota and USDA Animal and Plant Health Inspection Service quarantined Lake and Cook Counties in 2014.

Table 5.13-14. Gypsy moths trapped on all ownerships*

	2013	Severe winter 2013-2014	2014	2015	2016	2017
St. Louis Co.	4,130				94	261
Lake Co.	60,102				372	794
Cook Co.	6,044				440	96
Statewide			523	1,049		

* Minnesota Department of Agriculture traps gypsy moths to estimate populations.

Eastern Larch Beetle

Figure 5.13-42 show the statewide trends for eastern larch beetle. These insects attack tamarack trees. While the aerial survey did not pick up any larch beetle on the Superior NF, it is present, at least minimally, on the LaCroix District. Spatially, the beetle is moving east. Statewide there was a record-setting outbreak in 2017, so it is an emerging issue. The University of Minnesota (McKee and Aukema 2015) found that warm springs and summers increased the number of generations of beetles, increasing the population more quickly than expected.

One concern with tamarack mortality is losing forest cover in wetlands that can lead to stands becoming wetter and tree species not being able to regenerate or susceptible to non-native invasive species.. It is important to monitor yearly for the eastern larch beetle. The Forest may need to harvest or fell tamarack to slow the spread; however, the Forest Plan discourages tamarack harvest.

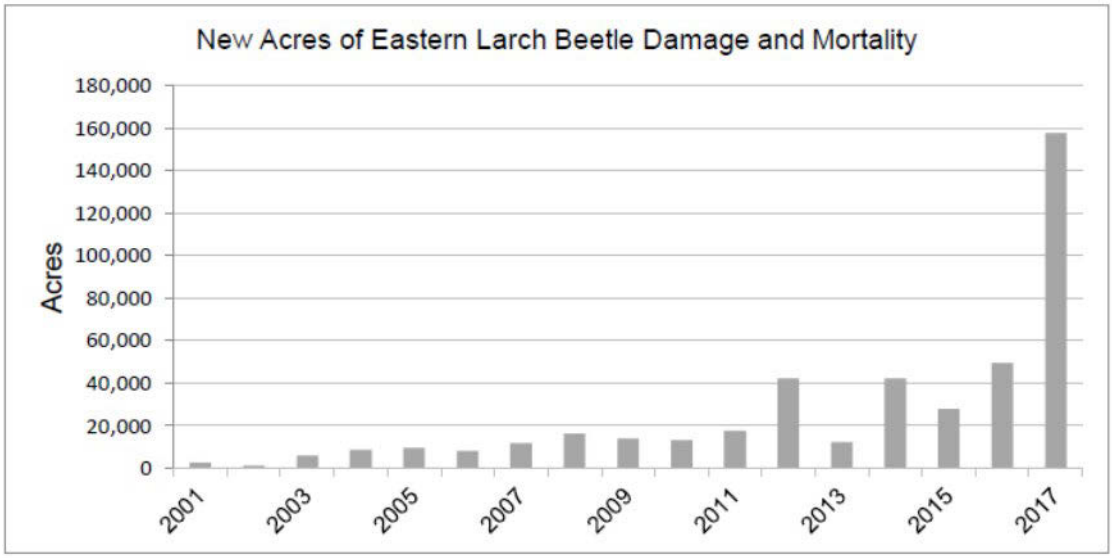


Figure 5.13-42. Acres of new eastern larch beetle damage and mortality statewide*

*From: MN DNR Forest Health Assessment Report for 2017.

Emerald Ash Borer (EAB)

The Superior NF has not documented this non-native invasive insect. The closest documented occurrence of EAB was in 2015 in Duluth.

Black ash decline has similar signs as an EAB infestation: dying twigs, dying limbs, and dead trees. The MN DNR stated, "Black ash decline is so common in the northern two-thirds of Minnesota that early detection of [EAB] in rural black ash swamps will be almost impossible" (MN DNR Forest Health Assessment Report for 2015).

Research suggests the pest is inactive only when temperatures dive 30 below zero; however, winter low temperatures are projected to continue to rise. Again, warmer winter temperatures increases the chance of establishment of EAB on the Superior NF in the future. The mortality rate of an infested tree is 100 percent, so it is important to continue to monitor and develop strategies for keeping tree cover in lowland hardwoods.

Environmental Stressors

Aspen decline

Decline is a result from multiple factors: drought, insects, diseases, poor site quality, and old age. In 2009, approximately 300,000 aspen-dominated acres experienced decline across the State. This peak results from a few successive years of drought. In 2013 on the Superior NF, the amount of aspen decline was still high (table 5.13-15); however, during 2016 and 2017, no aspen decline was mapped on the Forest. The reduction is mostly likely due to above average precipitation.

Wind damage

In July of 2016, straight-line winds blew down more than 13,000 acres on the Kawishiwi Ranger District. Much of the damage was in the BWCAW.

Red and White Pine Issues

High density, single species stands are always at more risk than more diverse stands managed at moderate densities. The MN DNR found 'prolific' *Diplodia sapinea* in red pine across the State, especially in wet years. This tip blight kills shoots that kills infected seedlings and stops growth of mature trees. Trees are most susceptible after damage from wind and hail. Wetter summers may also increase the already high white pine blister rust in northeastern Minnesota, so it is important to maintain plantings and natural regeneration with releasing and pruning.

5.13.5 Forest Condition and Restoration Need

This section is a culmination and synthesis of the four previous sections of the vegetation chapter to help answer the larger questions related to vegetation management at a landscape scale. Forest inventory and analysis (FIA) in partnership with the MN DNR Division of Forestry has periodically inventoried Minnesota forest resources many years. The latest inventory published was completed in 2013 and covers data collected from 2009 to 2013 (USDA 2016). At the time of publication, the Superior National Forest is working with Minnesota LiDAR imagery and other remote sensing data to better assess current forest condition and restoration need at the landscape scale across all ownerships. The data and their associated products will be ready for use sometime in 2019 and will inform the answers to the monitoring questions. Future monitoring and evaluation reports will incorporate this data and more fully address the questions related forest condition and restoration needs.

5.13.5.1 Monitoring Questions:

The following questions are from the Forest Plan matrix in chapter 4.

- *To what extent is the Forest providing a full range of vegetative communities that address diverse public interests and needs while contributing to ecosystem sustainability and biological diversity?*
- *To what extent is forest management, natural disturbances, and subsequent recovery processes changing vegetation composition and structure?*
- *To what extent is forest management, natural disturbances, and subsequent recovery processes restoring vegetation spatial landscape patterns?*
- *To what extent is forest management maintaining or restoring conditions that result from or emulate natural ecological process of fires, wind, flooding and insect and disease outbreaks?*

The drivers, indicators, and methods described in sections 5.13.1.1 through 5.13.4.1 apply to this sections analysis, discussion, and recommendations.

Analysis

According to the 2016 USDA report, paper birch and jack pine experienced high mortality. Birch volume decreased by nine percent and jack pine volume decreased by seven percent statewide. The highest volume of birch in the State is in Cook and Lake Counties. From the discussion on forest composition and age in section 1, this conclusion is not a surprise. Seeing the decrease spatially and across ownerships highlights a common issue in the Arrowhead.

There is a convergence of negative trends in Lake County, which coincides with the Kawishiwi, Lauentian, and Tofte Districts (see growth and mortality figures below). The analysis does not separate data by ownership, but the trends that relate to forest sustainability are striking and may warrant more investigation. Lake County has:

- Low growth rates.
- Highest mortality rate.
- Highest volume of jack pine in the State, with one exception.
- Highest volume of black spruce in the State, with one exception.
- Low removal rates.

Figures 5.13-43 and 5.13-44 display growth and mortality maps from USDA 2016, Minnesota Forests 2013, Northern Research Station, Resource Bulletin NRS-104.

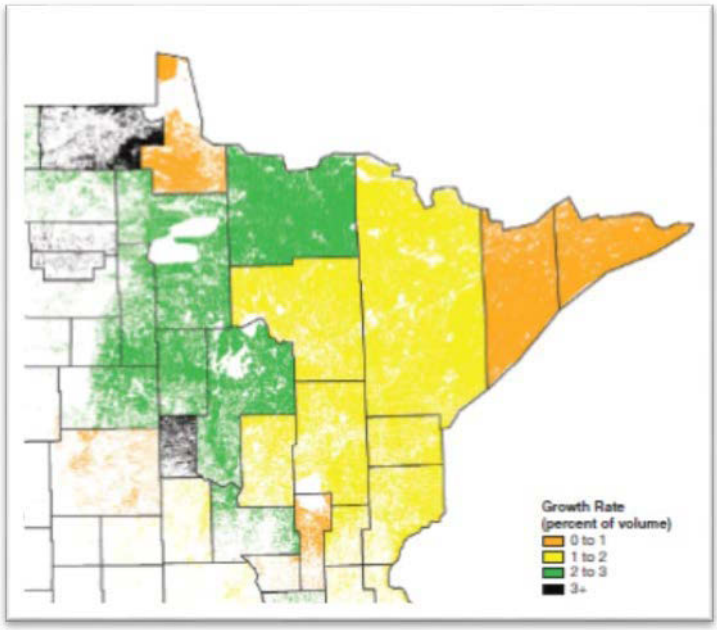


Figure 5.13-43. Growth rate map from USDA 2016 Minnesota Forests*

*2013 Northern Research Station, Resource Bulletin NRS-104

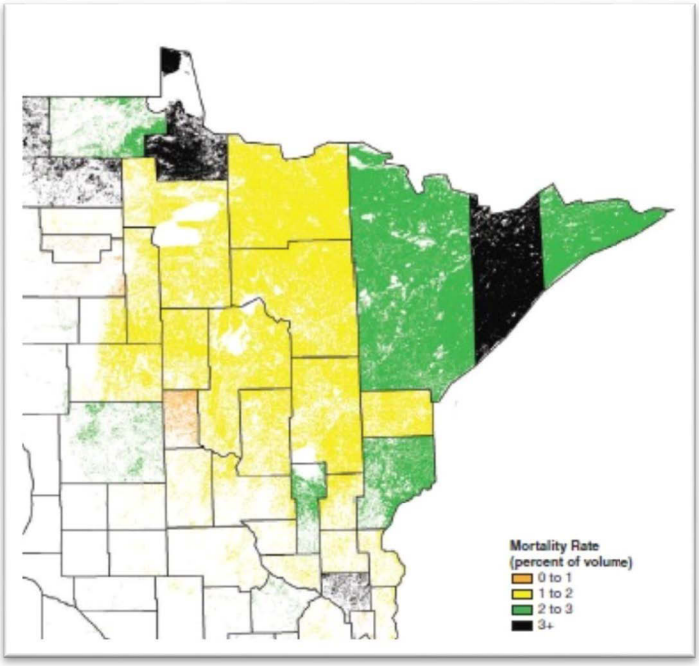


Figure 5.13-44. Mortality map from USDA 2016 Minnesota Forests *

*2013 Northern Research Station, Resource Bulletin NRS-104

Table 5.13-15. National Forest System acres of forested lowlands on SNF by district and forest type

Forest Type	Lau	Gun	Kaw	Lac	Tofte	Grand Total
Black ash-American elm/red maple	6,856	1,130	1,354	4,580	3,679	17,599
Black spruce	56,441	9,400	26,413	11,706	49,010	152,970
Mixed lowland hardwoods	10	55			26	92
Mixed swamp conifer	17,166	8,596	5,355	1,999	21,563	54,679
Tamarack	2,725	83	873	277	825	4,783
Grand Total	**83,198**	**19,264**	**33,995**	**18,562**	**75,103**	**230,122**

Source: T:\FS\Reference\GIS\r09_snf\Data\FSVegSPGeneral.gdb, September 2018

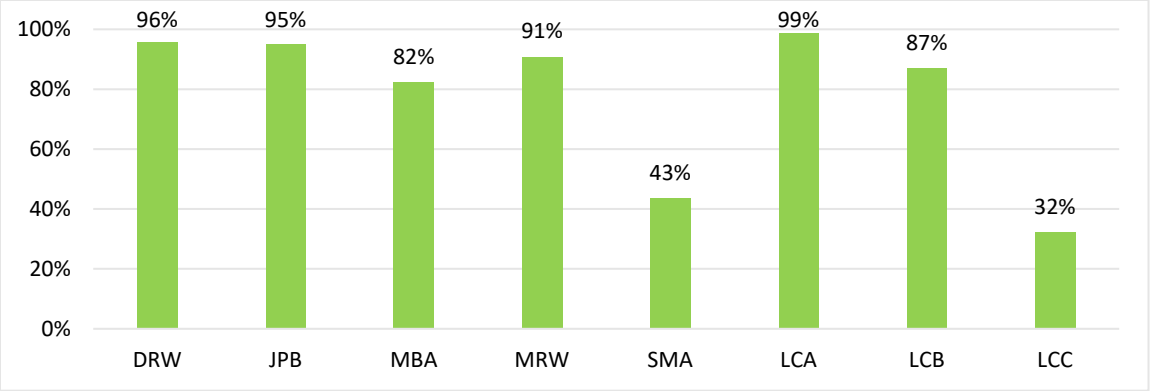


Figure 5.13-45. Percentage of landscape ecosystems covered by a NEPA project area decision by the end of decade 1 (2014)

Figure 5.13-45 shows that the NEPA process analyzed most LEs in the first decade. Thus, the changes in forest type and stand age capture a full decade of planning for most LEs, with the notable exception of lowland conifer and sugar maple.

Discussion

Based on monitoring discussed in sections 5.13.1.1 through 5.13.4.1, a full suite of vegetation communities still occurs on National Forest System lands contributing to ecosystem sustainability and biological diversity. However, concerns for ecosystem sustainability and biological diversity exist with a changing climate. Maintaining and increasing the resiliency of forested habitats is becoming increasingly important considerations in forest management. Managing for and maintaining biological diversity will become an increasing restoration need into the future.

Based on monitoring for vegetation composition, age class, species diversity, and MIH (section 5.13.1.1), the forest has generally gotten older, and experienced an increase in balsam fir and shrubs in the understory of some stands resulting from the forest aging and a reduction in disturbance. Some very slight shifts in forest composition have occurred with minor increases in some conifer species (primarily spruce-fir); however, Forest-wide, the most highly represented forest type is aspen (which has also exhibited a slow to moderate decline). Increased disturbance (both natural and through management) in the future would encourage greater desired vegetation composition and structure changes. Consideration for the greatest restoration needs are specific to each landscape ecosystem (see section 5.13.1.1 discussion on MIH for LE specific restoration needs). However, management should generally decrease aspen and spruce-fir forest types; treat more of the very old forest to create more young forest; and increase jack pine and other pine forest types.

Based on monitoring for vegetation spatial landscape patterns, the Forest is restoring mature upland and lowland forests. In general, the size of mature upland forest patches are increasing, mature and older upland forest patches are becoming more pine dominated; interior forest habitat in mature patches in increasing; and mature lowland forest patches are being maintained. However, forest management has fallen short of objectives to increase the average size of young forest patches and decrease management-induced edge density (fragmentation). Forest Plan direction drives restoration needs for management of forest spatial patterns in three different

spatial zones. Refer to section 2 and the recommendations section of this chapter for greatest restoration needs related to vegetation spatial patterns.

To what extent is Forest management maintaining or restoring conditions that result from or emulate natural ecological process of fires, wind, flooding, and insect and disease outbreaks?

Refer to Forest Insect and Diseases section 5.13.4.1.

Recommendations

Overall

- Decade 2 objectives are still relevant - Continue to manage forest vegetation towards LE objectives for the second decade (2024).
- The Forest should evaluate and document in the next M&E report decade 3 objectives and determine if continued movement towards those objectives is prudent.
- Continuing monitoring LE objectives: composition, age class, species diversity, and MIS; Along with vegetation spatial patterns, white pine, and insect and disease at the Forest scale.

Section 5.13.1.1 Landscape Ecosystem Objectives: Vegetation Composition, Age Class, Species Diversity and MIH

As summarized above, the general trends occurring across the forest are too few young age class acres and too many old age class acres. Further, the composition of these acres is off-target with too little jack pine on the landscape and overabundant aspen. Why is the Superior NF not meeting Forest Plan objectives for vegetation composition and age class? These observed trends can generally be explained by three different factors:

- A lack of disturbance on the landscape.
- A lack of resources to treat more acres through harvesting greater volumes of timber, removing biomass, and treating with non-harvest restoration.
- A lack of stand-replacing fire.

Historically, the forest experienced much greater rates of disturbance including more frequent fire return intervals, summer burns that were more likely to burn at the intensity of stand-replacing fires, and intentional fires set by Native Americans. Stand-replacing fires were also more common. Each of these factors allowed older areas of the forest to burn while providing opportunities for young seedlings and pioneer species to regenerate. Fire is a particularly important component in jack pine ecosystems and its exclusion brings challenges for creating young age classes. The exclusion of fire has likely also contributed to the overabundance of aspen on the landscape as this species is fire intolerant and older stands would die off in intense fire.

While not a direct substitute for fire, timber harvest can mimic some of its benefits on the landscape. As the forest's managers, the SNF can try to mimic historic effects of disturbance in all LEs by treating more acres through timber harvest, non-harvest site prep, biomass removal etc. However, a lack of resources (staff, time, and money) has kept us from being able to keep up the pace needed to shift these age classes, composition structures, and MIHs to desired levels. Below are offer some management recommendations to work towards meeting second decade objectives:

- Treat more of the very old stands to create more young forest-- Young forest (0-9 years old) has been diminishing over the past decade as the forest matures and landscape disturbance (both natural and human caused) is not keeping pace to fully meet Forest Plan objectives. Similarly, there is an over-abundance of old and multi-aged forest (particularly very old aspen, birch, aspen-conifer mix, upland spruce-fir and jack pine which tend to have lower timber value but the highest restoration need and associated costs to treat). The Forest can achieve Plan objectives through balancing young and very old forest by treating more of these very old stands to create more young forest (particularly young aspen, birch, aspen-conifer mix and jack pine) through a variety of management tools including timber harvest, biomass removal, and prescribed fire. The number of old stands dominated by trees that are relatively short lived (e.g., aspen, fir) is very high, over 60 percent of forested stands on the national forest (730,000 ac). These acres are also contributing to the imbalances in vegetation composition and MIHs.
    - One potential strategy for increasing the amount of young forest on the landscape is to allow more flexibility with "leave trees" in stand treatments. Best management practice guidelines call for of 6-12 reserve trees. While this quantity is appropriate in many areas, it can restrict stands of greatest restoration need, rendering them uneconomical in timber harvest and substantially reducing options to restore resiliency in these areas. The Forest recommends reviewing and possibly modifying leave tree guidelines and best management practices at the Forest and project levels. This would require planning and monitoring at the project level.
    - A second strategy for increasing the amount of young forest is to increase the use of tools such as Good Neighbor Authority, stewardship contracting, and stewardship agreements to treat lower value stands that are not economical with traditional timber sales.
    - A third strategy for increasing young forest is encouraging more diverse markets for low valued timber.
    - A fourth strategy of increasing young forest is to treat larger landscapes and acreages.
- Decrease aspen and spruce-fir forest types--Aspen and spruce-fir forest types are consistently exceeding and/or are projected to exceed composition and MIH objectives in many LEs. In the future, spruce-fir stands are at a greater risk of spruce budworm and forest tent caterpillar infestation. At a national level, Lake County and eastern St. Louis Counties were identified as a hot spot for defoliation from these insect pests (USDA FS R&D GTR SRS-233). Spruce-fir stands (without a strong hardwood component) may be the best opportunities for conversion to jack pine.
- Consider prioritizing harvest and other fuel reduction activities in Lake County stands of black spruce and jack pine (See Section 5-Forest Health and Section 4- Restoration Needs). Lake County has some of the highest mortality rates (average annual live tree mortality on forestland as a percent by volume) (USDA FS No. Res. Stn, Minn. Forests 2013). Lake County also has some of the highest volume of black spruce and jack pine in Minnesota (same citation), making this area of the forest very vulnerable to invasions from spruce budworm and dwarf mistletoe and increased fuel hazards from dead and dying trees.
- Increase jack pine--Jack pine forest is a foundation of the fire-adapted ecosystems common in NE Minnesota and important for species that depend on it. Over the decades, jack pine has decreased substantially due to forest succession and fire suppression. To maintain iconic

forests of the Arrowhead, increase the amount of jack pine in these intermixed landscapes, with a diversity of other tree species to maintain stand resiliency. While jack pine occurs in all the upland LEs, most of it is in the JPBS LE. The Forest Service manages 83 percent of the Jack Pine/Black Spruce LE in the northern superior uplands section (Forest Plan Table NSU-1). The Superior NF has an opportunity to help move all ownerships toward common goals.

- Increase the use of artificial regeneration methods to increase jack pine and upland jack pine-black spruce forest types (FTs 1 and 17).
- Increase active management in FTs 1 and 17
- Decrease the amount of broadleaf species in FTs 1 and 17
- Invest in resilient and climate adapted species--Northern boreal forests are projected to transition to deciduous forest. During the transition, there will be an increase in fire risk if grasses and brush species dominate the understory where conifer seedlings used to grow. Protect species that are more likely to increase in abundance with the changing climate. For instance, reduce fuels in red and white pine stands. Reduce stocking in deciduous stands. Aspen continues to be the most abundant forest type across all ownerships. Aspen is projected to decrease in abundance with changing climate. The Superior should consider developing an interagency strategy for human and natural communities to respond if this most common forest cover type fails.
- Increase treatment of lowland black spruce—Dwarf mistletoe impacts many lowland black spruce forests and they may be unable to regenerate young black spruce after harvest or natural disturbances. These sites are changing to brush such as tag alder, which has low value as wildlife habitat. Other forested lowlands have native (larch beetle) and non-native (emerald ash borer) pests that can dramatically change stand composition and function. The Lake County portions of Laurentian and Tofte Districts are especially facing these threats. Trees in lowland forests play an important part in regulating hydrology. When trees die in lowland forest, water levels can rise so forest managers have few options to reestablish forest cover. Prioritizing lowland forest restoration in these areas would help to reduce the potential for multiple defoliation and mortality factors occurring at one time in one watershed.
- Maintain planted white pine--Since 2004, the Superior NF has increased stands dominated by white pine by 7,000 acres through planting over five million white pine seedlings. What is important now is continued care/tending and maintenance to ensure these trees provide mature forest for the future to meet long- term 100-year objectives.
- Monitor inter-planting of white pine –There is a sense that there is more white pine on the landscape, particularly as a component of other forest types, than databases account for. For the next monitoring report, monitor and report out on the acres of inter-planted white pine that has occurred by LE to give a better picture to meet objectives for white pine and to guide future management decisions of white pine.
- Manage for diversity in aspen and red pine - Managed aspen and red pine stands tend to have fewer species and less structural diversity that can put them at risk from insect and disease

out breaks. These stands need treatments to improve their diversity and resilience to a changing climate.

- Greatest management indicator habitat restoration needs by LE
  - Management of the oldest aspen-birch, mixed aspen conifer, and upland spruce-fir forest to create and restore young aspen-birch, mixed aspen conifer habitat for restoring the desired balance of habitat in the MBA LE (figure 5.13-13).
  - Management of the oldest aspen-birch, mixed aspen conifer, and jack pine forest to create and restore young aspen-birch, mixed aspen conifer, and jack pine habitat for restoring the desired balance of habitat in the JPB LE (figure 5.13-15).
  - In the DRW LE, consider options for restoring and promoting old and multi-aged spruce-fir forest conditions in the oldest jack pine forest habitats (figure 5.13-17).
  - Management of the oldest aspen-birch, mixed aspen conifer, and spruce-fir forests to create and restore young aspen-birch mixed aspen confer and jack pine habitat for restoring the desired balance of habitat in the MRW LE (figure 5.13-19).

Section 5.13.2.1 -Vegetation Spatial Patterns

- Conduct a Forest-wide patch assessment to determine where the best opportunities are for maintaining and managing forest patch resources at a landscape scale.
- Evaluate the concern about the fragmentation of 1,000-plus acre mature patches in project planning and provide guidance to project interdisciplinary teams.
- Closely monitor interior upland forest habitat in spatial zone 1 to ensure that interior upland-forest habitat conditions are developed and maintained.
- Continue to seek opportunities to create larger patches of young forest resulting in an increase in the average patch size and a decrease in management inducted edge density.
- Conduct a Forest wide assessment of pine patches, as not all pine patches are equal for habitat quality. Develop a long-term strategy for their management, in particular, where management should focus on old growth characteristics versus management for pine plantations.
- Obtain and incorporate higher resolution LiDar data. The Forest is currently developing an analysis to assess patch condition into the next Forest Monitoring and Evaluation report.

Section 5.13.3.1 White Pine

- Maintain planted white pine. Since 2004, the Superior has increased the amount of stands dominated by white pine by 7,000 acres. This is due to planting over five million white pine seedlings. What is important now is continued care/tending and maintenance to ensure these trees provide mature forest for the future to meet long-term 100-year objectives.

Section 5.13.4.1 Forest Insect and Disease

- Spruce Budworm - Examine Forest Plan guidance for flexibility in the guidance when treating stands for insects and diseases, especially leave trees and reserve areas. These stands are typically old (80-plus years) mixed aspen-birch-spruce-fir stands. If harvesting all trees, some low-value and low volume stands may be marketable.

- Eastern Dwarf Mistletoe –
  - Develop prescriptions for prescribed burning in lowland black spruce.
  - Prioritize DMT treatment before winter operations become too difficult due to warmer winters.
  - Increase training for DMT identification.
  - Examine Forest Plan guidance for flexibility in the guidance when treating stands for insects and diseases, to allow effective treatments limiting DMT infections.

Section 5.13.5.1 Forest Condition and Restoration Needs

- Incorporate results from the new all-ownership stands-layer in the analysis of Forest condition and restoration needs in future monitoring and evaluation reports.

Needed Research

- Evaluate JPB objectives for forest type and age; however, the Forest should still make more effort in creating more young jack pine.

Potential Changes Monitoring

- To what extent are conditions moving toward short-term (1-20 years) and long-term (100-year) objectives at the landscape ecosystem, management areas, and other appropriate landscape scales?
  - Look at the change of broad leaf species in fire-dependent LEs. Broadleaf species can change stand dynamics by altering how the system response to fire. (Handler et al. 2017)
  - The decrease in jack pine is Statewide, not just on the Superior NF, from 2003 to 2013 (MN DNR 2013). This is an opportunity to monitor with other agencies and organizations.

The discussion above on tree species diversity cites many numbers on how many seedlings were planted. This number, however, does not speak to seedling survival. This identifies a monitoring need where it would be useful to have numbers on how many seedlings survived as a percentage versus the number planted. This need could help us better evaluate why the Forest met some objectives, and how to improve planting techniques in the future.

- Are insects and diseases populations compatible with objectives for restoring or maintaining healthy forest conditions?

Monitor the condition of black ash stands – forest type, age, stocking, within-stand diversity, and EAB infestation.

References

Fraser R. McKee and Brian H. Aukema. 2015. Agricultural and Forest Entomology (2015), 17, 102–112.

Handler et al. 2014. Minnesota forest ecosystem vulnerability assessment and synthesis. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. GTR-NRS-133. www.nrs.fs.fed.us/pubs/45939

Handler, S., K. Marcinkowski, M. Janowiak, and C. Swanston. 2017. Climate change field guide for northern Minnesota forests: Site-level considerations and adaptation. USDA Northern Forest Climate Hub Technical Report #2. University of Minnesota Collage of Food, Agriculture, and Natural Resource Sciences, St. Paul, MN. 88p.

Minnesota Department of Natural Resources 2013. Forest Health Annual Report. Division of Forestry, Forest Health Unit, St. Paul, MN.

Minnesota Department of Natural Resources 2014. Forest Health Annual Report. Division of Forestry, Forest Health Unit, St. Paul, MN.

Minnesota Department of Natural Resources 2015. Forest Health Annual Report. Division of Forestry, Forest Health Unit, St. Paul, MN.

Minnesota Department of Natural Resources 2016. Forest Health Annual Report. Division of Forestry, Forest Health Unit, St. Paul, MN.

Minnesota Department of Natural Resources 2017. Forest Health Annual Report. Division of Forestry, Forest Health Unit, St. Paul, MN.

USDA 1977. Managers' handbook for black spruce in the north central states. GTR NC-34. North Central Forest Experiment Station. St. Paul. MN.

USDA 2016, Minnesota Forests 2013, Northern Research Station, Resource Bulletin NRS-104.

USDA 2018. Trends in Tree Stems per Acre for Selected Species in the Laurentian Mixed Forest Province in Minnesota. Forest Service, Forest Inventory and Assessment.

USDA 2018b, Forest health monitoring: National status, trends, and analysis 2017. Forest R&D Southern Res. Station, GTR SRS-233, June 2018, Eds. K.M. Potter and B.L Conkling.

5.14 Water Resources

5.14.1 –Water Quality

The Superior National Forest (SNF) monitors water quality by numerous ways within the SNF. The SNF has collected data from streams between 2011 and 2015 in the area of mining interest. These data are entered into the U.S. Geological Survey database and will be the subject of a report that is expected to be completed and available to the SNF and the public in 2019.

5.14.1.1 Water Quality Monitoring Question

To what extent is Forest management affecting water quality, quantity, flow timing and the physical features of aquatic, riparian, or wetland ecosystems?

Monitoring Indicator(s)

Evaluating the water quality on the Forest addresses the monitoring question. The activity is prescribed by all the watershed desired conditions and objectives in the Forest Plan, with the possible exception of D-WS-14, plus O- RWA-1 D-PH-3, D-PH-4, O-PH- 3, O-TS-4 and O-TS-5. Water quality parameters including cations, anions, turbidity, pH, dissolved oxygen, temperature, organic carbon, suspended solids concentration, and some nutrients. Specifically, designation by the Clean Water Act (CWA) supports the designated uses of the groundwater, streams, lakes, wetlands, and beaches.

Monitoring Frequency

The testing is not done Forest-wide at an identified frequency. Rather, the Forest and others perform the testing at different times across the Superior and by others, such as the Minnesota Pollution Control Agency (MPCA). They are presently on a ten- year cycle of intense monitoring of watersheds in the State.

Background & Driver(s)

The CWA manages water for multiple uses including ecological function and human services. The MPCA administers the CWA for the U.S Environmental Protection Agency.

Results

The MPCA has completed their monitoring report for all of the planning watersheds on the SNF except the Rainy River – Rainy Lake Watershed in the northwest portion of the SNF (see figure 5.14-1). As shown in figure 5.14-2, the MPCA has identified 337 lakes within the SNF as 'impaired' according to the CWA. However, all but three lakes are listed due to mercury (figure 5.14-3). Mercury is considered an atmospheric source and the U.S. Environmental Protection Agency approved Minnesota's Statewide Mercury Total Maximum Daily Load study in March 2007 to address these impairments. Blueberry Lake and Echo Lake are shallow lakes and although they have elevated nutrient concentrations, these elevated nutrient values are considered natural conditions. Hence, while the elevated levels in these lakes classifies them as "impaired" by the CWA, the MPCA considers these conditions to reflective of natural background because of the undeveloped nature of the watershed and shallow depth. The only lake on the SNF that exceeds the anticipated nutrient concentrations is Myrtle Lake. This lake has a developed shoreline and needs a total daily maximum load (TMDS) study to determine the source of the elevated nutrient concentrations and identify appropriate mitigation measures.

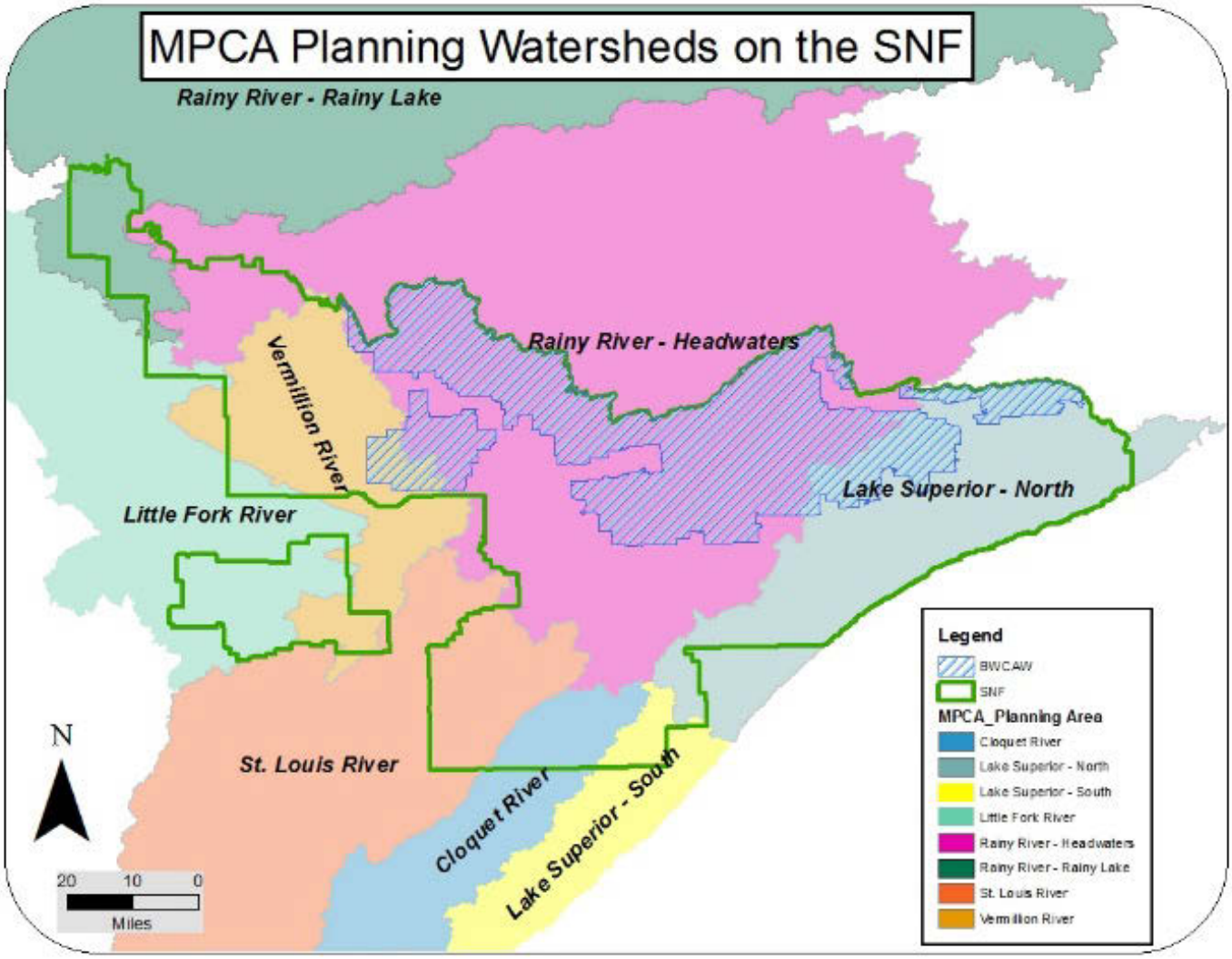


Figure 5.14-1. MPCA planning watersheds on the SNF

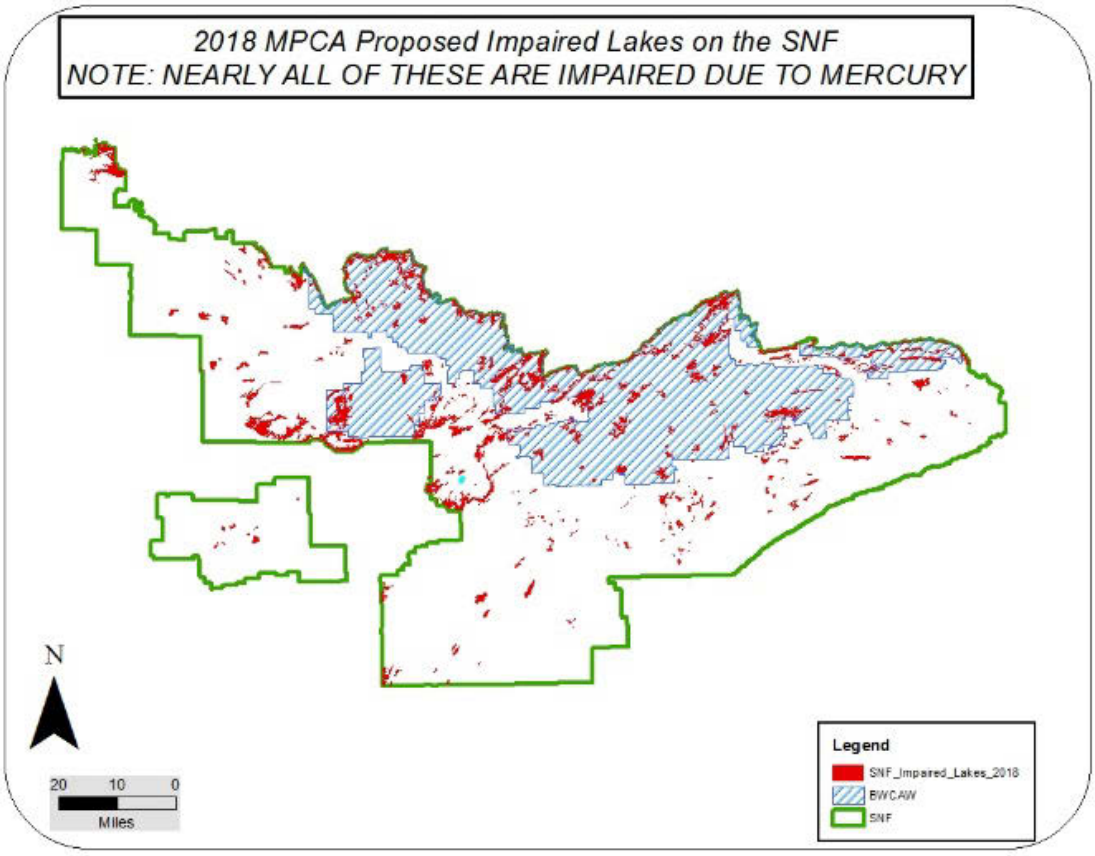


Figure 5.14-2. MPCA impaired SNF lakes

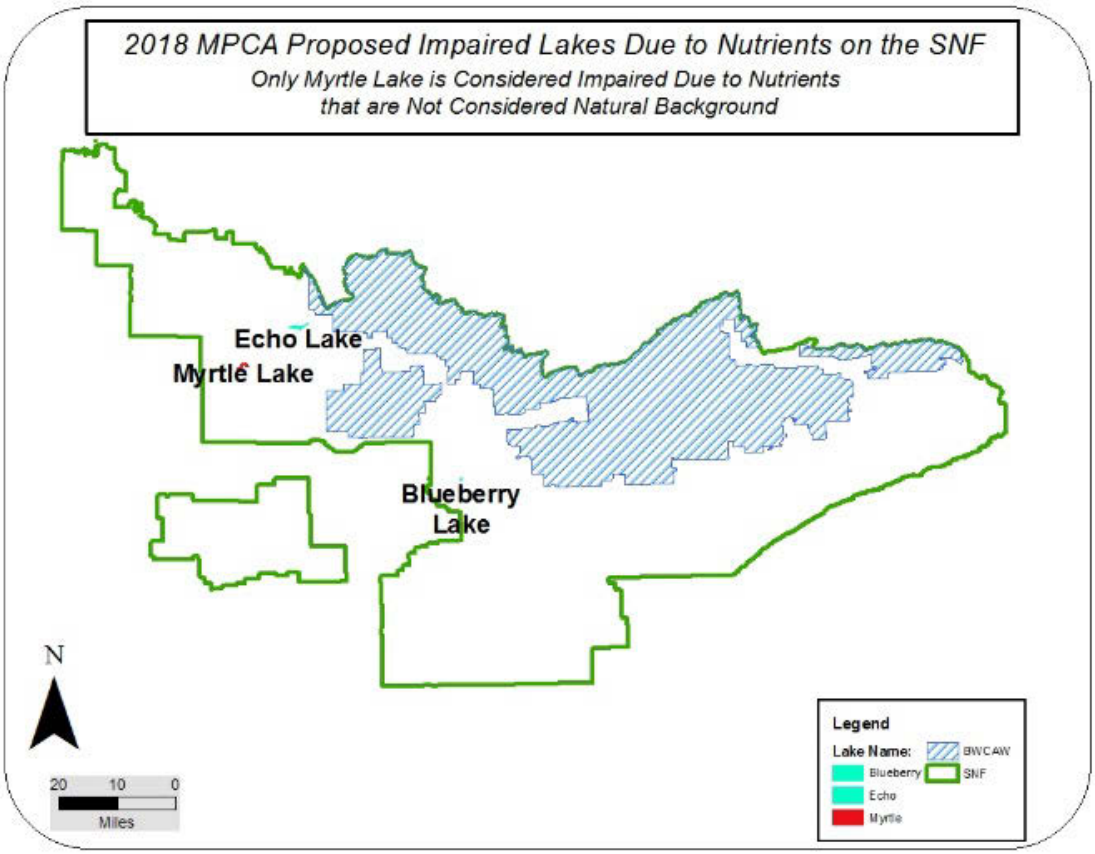


Figure 5.14-3. MPCA nutrient impaired SNF lakes

Nineteen (19) of the 32 stream reaches considered impaired by the MPCA are due to mercury. Five (5) others are considered impaired for other parameters, but are reflective of natural background conditions. The remaining eight streams considered impaired are listed below in table 5.14-1 and shown in figure 5.14-4.

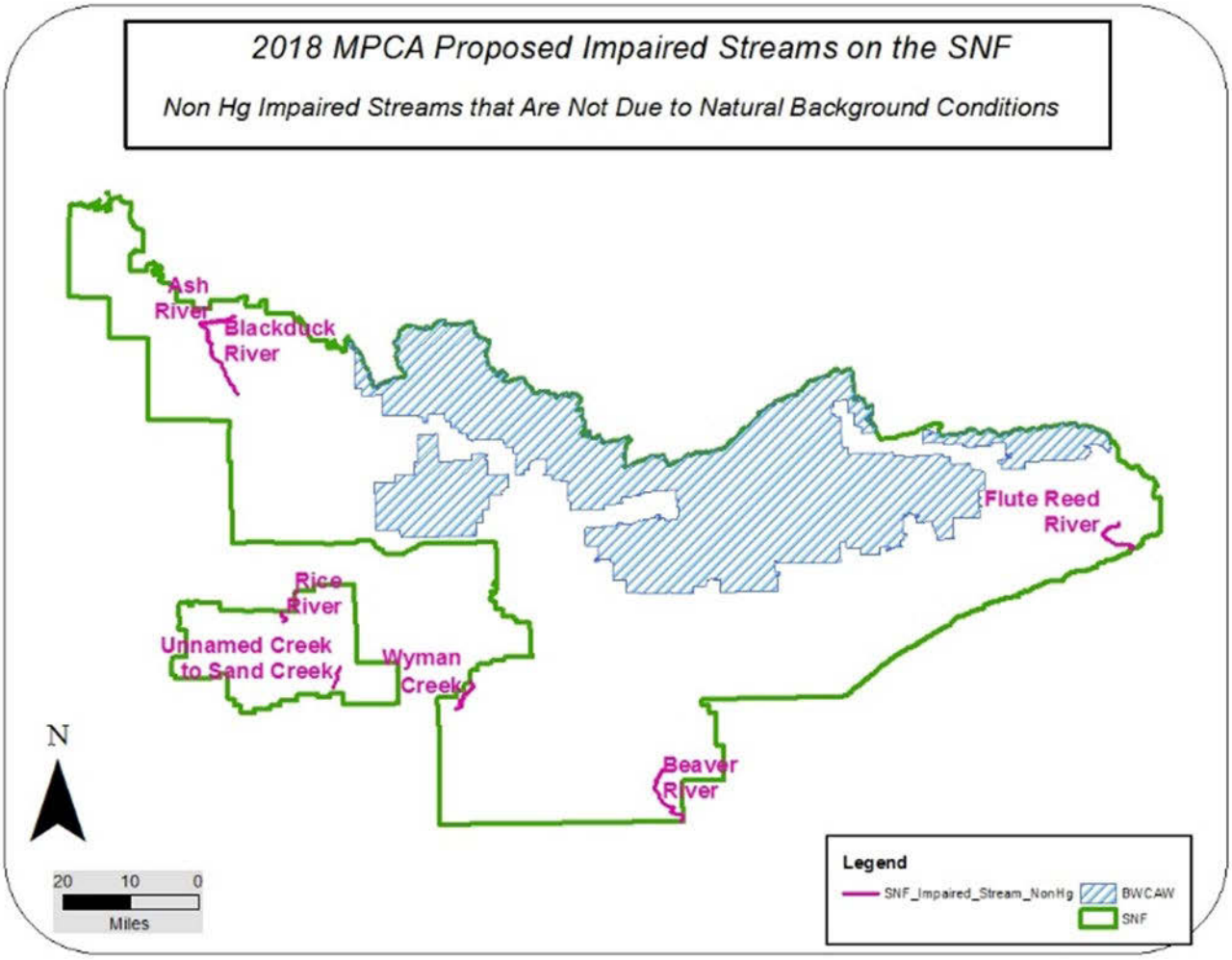


Figure 5.14-4. MPCA impaired streams

Table 5.14-1. Summary of MPCA impaired streams (excluding mercury and natural background impairments)

Stream	Reach Description	Length (miles)	Parameter	Comment
Ash River	Blackduck R to Ash River Falls	12.5	Total Suspended Solids (TSS)	*MPCA staff observed locations of stream bank erosion in the vicinity of a cattle pasture/farm near the Black Duck River intensive water chemistry station (and nearby tributary streams), as well as areas of unstable steam geomorphology in other stream reaches within the subwatershed. Forest harvest has been considerable in portions of these subwatersheds since ~ 2000 (MPCA, 2017)*
Blackduck River	Headwaters (Blackduck Lk 69-0842-00) to Ash River	16.1	Total Suspended Solids (TSS)	
Unnamed Creek	Headwaters to Sand River	4.0	Dissolved Oxygen (DO) Fisheries Biology	*The tributary to Sand River did not support aquatic life based on poor FIBI results. The fish community was comprised of two species (central mudminnow and white sucker) and was largely dominated by central mudminnow. Both of these species are tolerant to stressful conditions such as low dissolved oxygen and high sediment, with central mudminnow being considered very tolerant. The macroinvertebrate community had good taxa diversity and indicated support for aquatic life. Habitat conditions based on Minnesota Stream Habitat Assessment (MSHA) scores were good and similar between stations. (MPCA, 2018)*
Rice River	Johnson Cr to Little Fork River	35.0	Total Suspended Solids (TSS)	Impaired for aquatic life use due to a poor fish community; *"The low fish IBI score could be attributed to localized land use practices upstream of the site, such as: feedlots, treatment ponds draining directly into the Rice River, and lack of an in-tact riparian due to cattle grazing (MPC,A 2011)*
Flute Reed River	Unnamed Creek to Lake	0.8	Turbidity (T)	USFS owns less than 9% of the land in the watershed
Flute Reed River	Headwaters (Moosehorn Lk 16-0015-00) to Unnamed Creek	10.3	Total Suspended Solids (TSS)	USFS owns less than 9% of the land in the watershed
Beaver River	Headwaters to Lake Superior	23.4	Fisheries Biology Turbidity (T) pH Mercury in Water (Hg-W)	There is an existing tailings basin that is considered to be a contributer to the impairment
Wyman Creek	Headwaters to Colby Lk	10.0	Total Suspended Solids (TSS)	Headwater is a taconite mine facility
	TOTAL	112.0		

In cooperation with Vermillion College, the MPCA also collected water quality samples from Alton Lake, Caribou Lake, and Ensign Lake within the BWCAW in 2014 and 2015 (figures 5.14-5 and 5.14-6). The purpose of this sampling effort was to provide insight on how public campsite use could potentially influence algae blooms within the lake. The SNF recreation staff sampled the three lakes as they considered them to receive more use within the BWCAW. Table 5.14-1 displays the selected physical characteristics of the sampled lakes. The shoreline density of campsite development (shoreline miles per campsite) is similar. However, they differ in size (Ensign Lake is 5.7 times larger than Caribou Lake), estimated flushing rate, and other parameters.

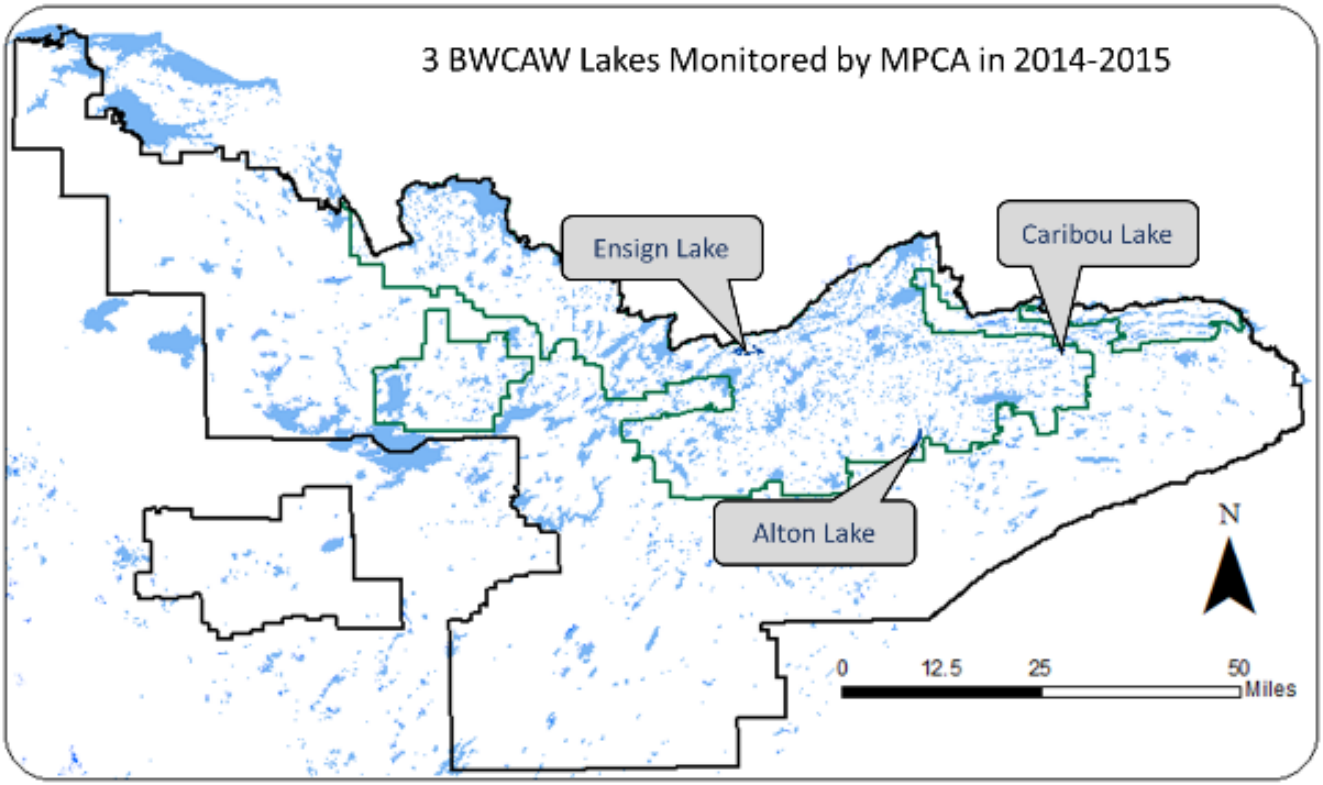


Figure 5.14-5. BWCAW/Vermilion College lakes monitored by MPCA in 2014-2015

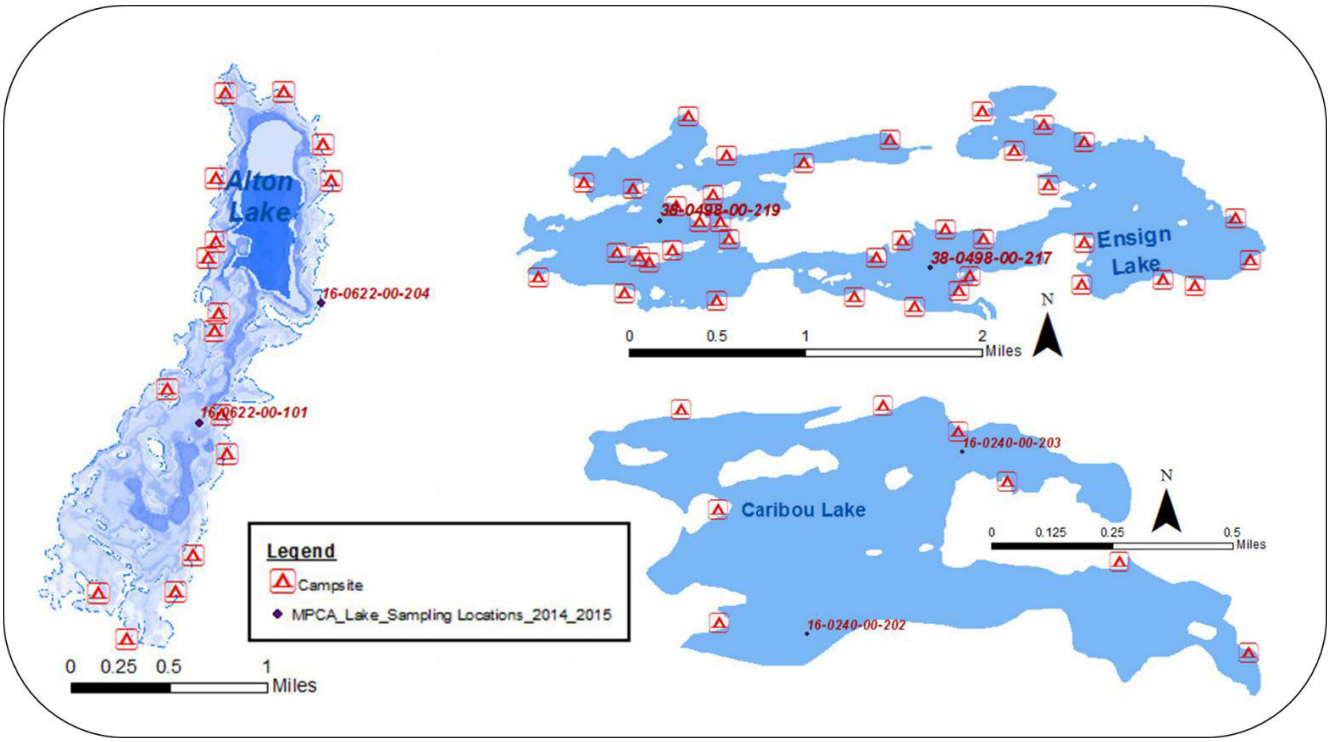


Figure 5.14-6. Detail of MPCA/Vermilion College BWCAW lake monitoring and campsite locations

Table 5.14-2. Summary of MPCA/Vermilion College BWCAW monitored lakes (2014-2015)

Lake Name	Alton	Caribou	Ensign
Mn DNR Inventory Number	16-062200	16-024000	38-0149800
Lake Area (ac)	969	246	1,411
Average Depth (ft)	23	--	--
Maximum Depth (ft)	72	26	30
Contributing Drainage Area (ac)	2,690	3,240	51,450
Shoreline Length (miles)	15.4	7.6	27.9
% Littoral Area	38%	83%	48%
Lake Trout Lake	Yes	No	No
Number of Campsites	16	8	37
Watershed / Lake Area Ratio	2.8	13.2	36.5
Flushing Rate (years)	32	4.1	1.1
Lake Area / Campsite (ac / site)	60.6	30.8	38.1
Lake Shoreline Length / Campsite (mi/site)	1.0	1.0	0.8
Overall Eutrophic State Index (TSI)	35 - Oligotrophic / Mesotrophic	44 - Mesotrophic	42 - Mesotrophic
1974 Sensitivity Estimate	Somewhat Sensitive	Moderately Insensitive	Somewhat Insensitive
1977 Algae Bloom Frequency	*None Identified*	*None Identified*	Occassional

During 2014, five monthly site visits occurred between May and September and four monthly site visits occurred between June and September in 2015. Surface water quality samples collected and analyzed several parameters including chlorophyll-a, and total phosphorus at two sites during each site visit on Caribou and Ensign Lakes. A single sample was collected from Alton Lake; May's sample was taken at a different location than the other dates in 2014.

Phosphorus and chlorophyll-a concentrations are dependent upon numerous influences such as, but not limited to, water temperature, recent weather patterns, riparian and watershed development patterns, lake volume, and contributing watershed and lake area ratio. Large amounts of data are needed to discern the relative influences of these parameters for the setting of interest.

The MPCA has defined a cold-water lake total phosphorus concentration less than 15 µg/l in the 'Northern Lakes and Forest Ecoregion' as fully supporting a cold-water fishery, primary-contact recreation (swimming), and aesthetics beneficial uses. Primary-contact and aesthetics are considered fully supported with a total phosphorus concentration less than 30 µg/l in the Northern Lakes and Forest Ecoregion.

Alton Lake is the only trout lake (table 5.14-2). Figure 5.14-7 displays the total phosphorus concentration results of the 2014 sampling efforts. Precipitation prior to the water sample collection was assessed using daily rainfall estimates from radar interpretation by the National Weather Service (National Weather Service, 2019). In addition, in 2014, there was a measurable precipitation event prior to sample collections for all the lakes in May, June, and July; and in August for Ensign Lake. Rainfall events ranged from approximately one-half inches to greater than one inch of precipitation.

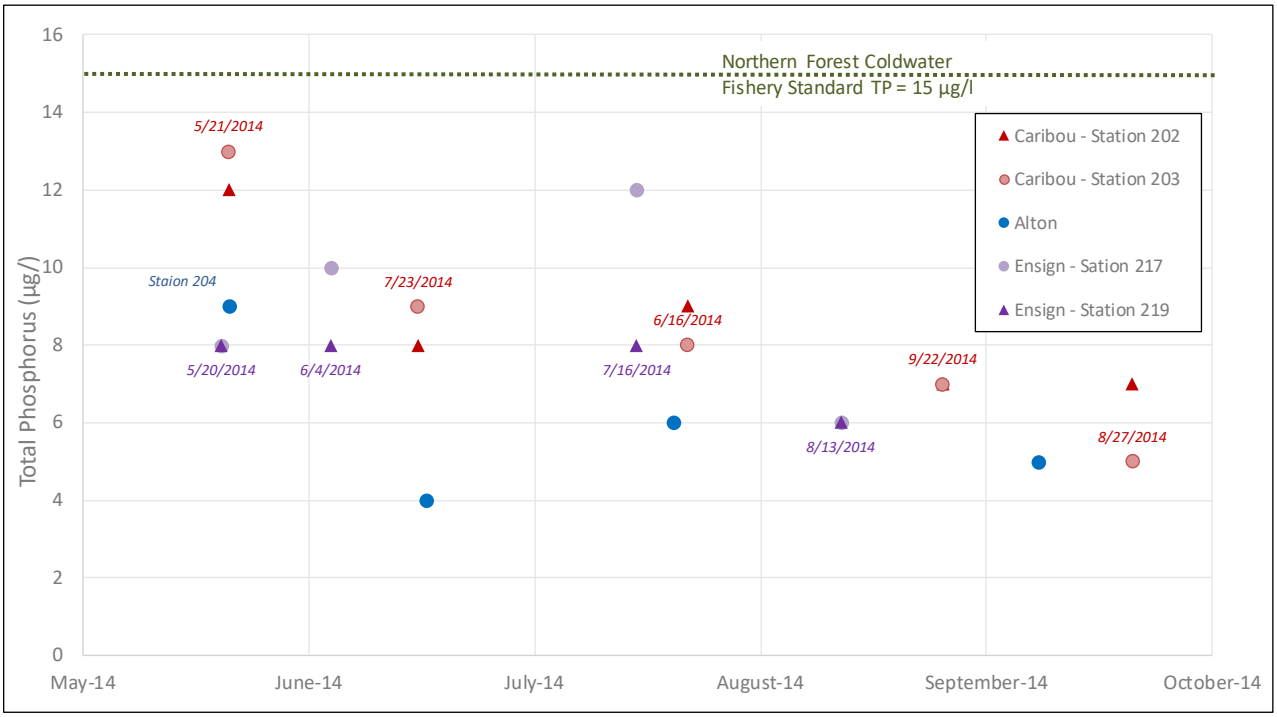


Figure 5.14-7. Total phosphorus concentrations of BWCAW lakes sampled by MPCA and Vermilion College

The MPCA did not have detailed data for the 2015 data collection period. However, the MPCA offered a cumulative seasonal average of the total phosphorus and chlorophyll-a concentrations (figure 5.14-8).

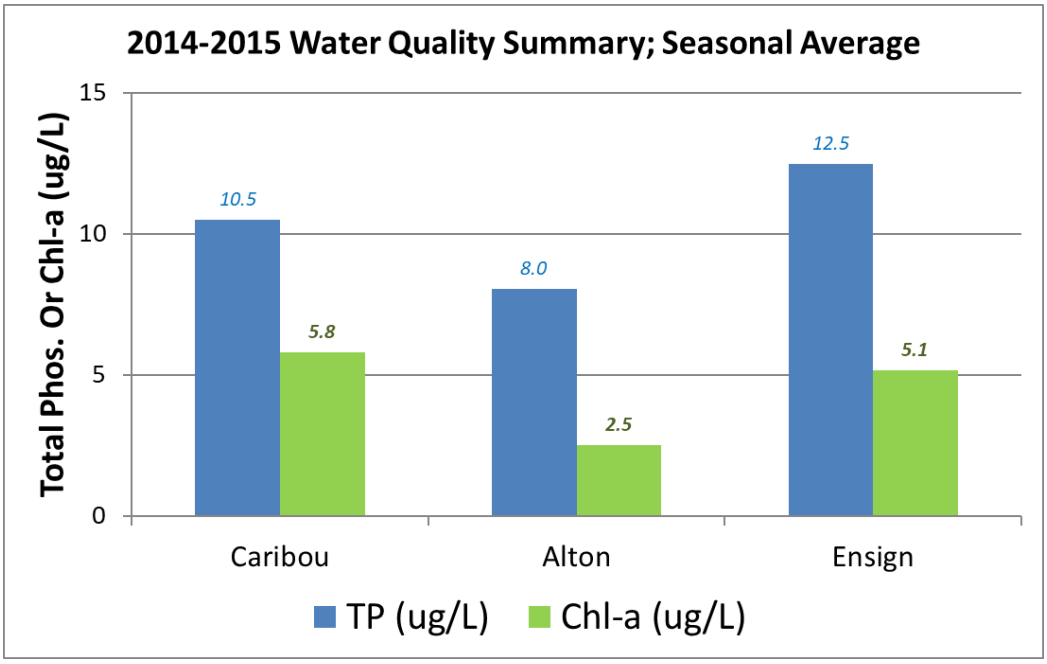


Figure 5.14-8. Cumulative seasonal average water quality of sampled BWCAW lakes. Sampled by MPCA and Vermilion College

All of the 2014 total phosphorus concentrations and the cumulative seasonal average concentrations, even within Caribou and Ensign Lakes, were below the cold-water fishery standard of 15 µg/l. All three lakes are meeting the MPCA water quality standards. The data collected can help provide a baseline of data for future comparison.

Discussion

Based upon the results of MPCA's intensive water quality monitoring effort and selected sampling of three lakes in the BWCAW, forest management activities of the SNF do not impair the designated uses of waters on the SNF and meet Forest Plan objectives.

5.14.2 Water Resources – Drinking Water

The SNF monitors drinking water facilities in accordance with Minnesota Department of Health (MDH) requirements for the protection of SNF users.

5.14.2.1 Drinking Water Monitoring Question

Does water in the Superior National Forest-(drinking water sources and swimming beaches) meet standards of quality protective of human health and aesthetics?

Monitoring Indicator(s)

The Forest addresses this monitoring question by evaluating whether drinking water in SNF campgrounds and facilities are consistent with the Forest Plan objectives summarized below:

- **Objective. O-PH-1.** Public and non-public water and wastewater systems are updated, maintained, and managed to the standards set forth in the appropriate federal guidelines and applicable State standards during this plan period.
- **Objective. O-PH-4.** Forest owned facilities and designated recreation sites and/or natural resource amenities are inspected and managed to ensure safe operation**.**
- **Objective.O-PH-3.** Known abandoned wells will be grouted and unused wells will be capped and maintained to prevent groundwater contamination.

The indicator of effectiveness is the compliance with Minnesota Department of Health (MDH) standards.

Monitoring Frequency

Wells are sampled monthly for e-coli when they are available for use. No sampling occurs when they are not being used (such as during the winter at closed campgrounds).

Background & Driver(s)

The SNF monitors drinking water facilities for the protection of SNF users. They test the water quality of 47 SNF wells for e-coli and nitrates as part of the responsibilities of providing water to the public and SNF employees. Figure 5.14-9 displays a map of the tested wells.

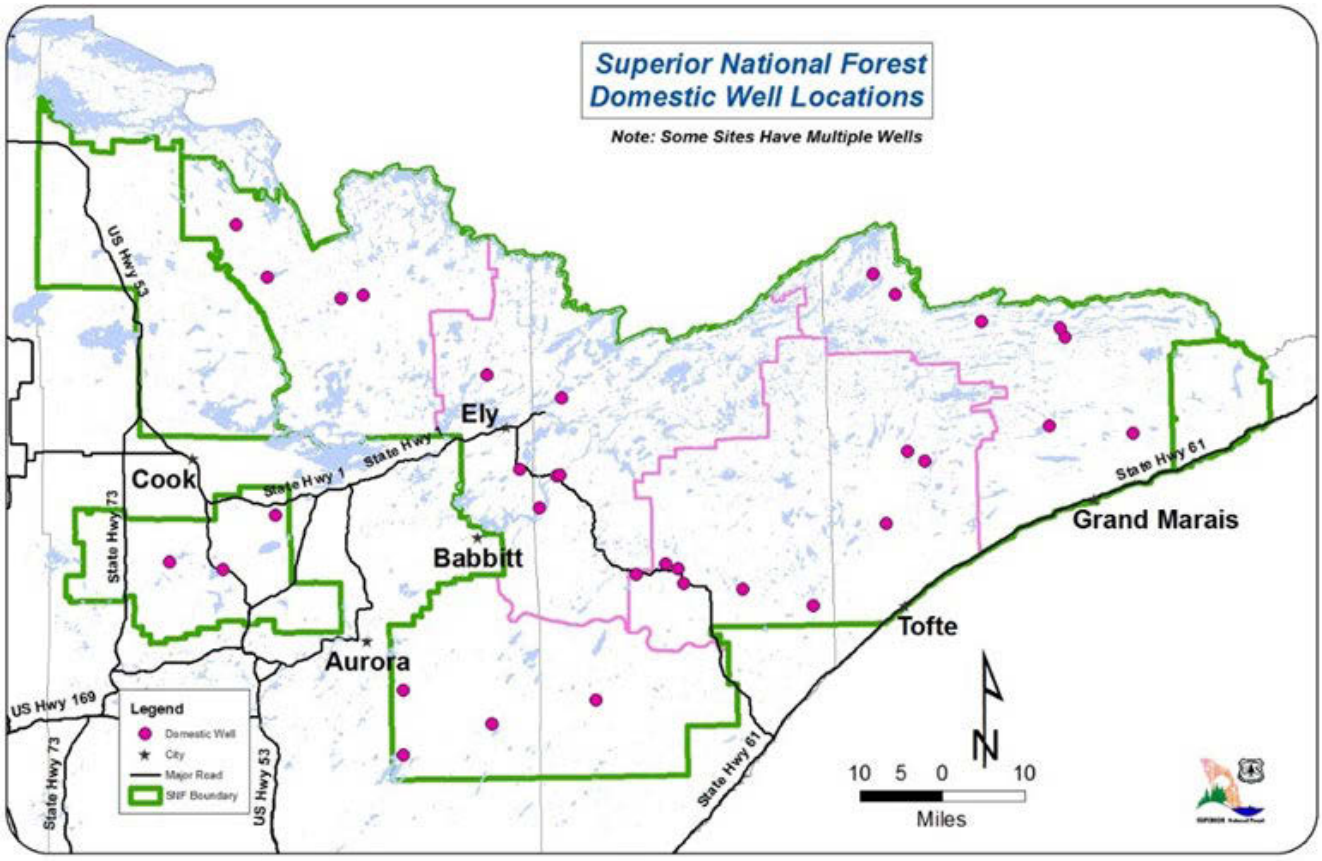


Figure 5.14-9. Locations of SNF tested well sites

Total coliform

The SNF maintains a State-certified lab at the Kawishiwi Ranger District in Ely, MN (State of MN Certified Lab #027-137-120, USEPA Lab #MN01048) for testing drinking water samples for e-coli. Monthly samples were collected during the period of operation and analyzed in accordance with the Minnesota Department of Health (MDH) approved standard operations procedures (SOP) and quality assurance (QA) manuals for the lab.

Superior staff retest and treat the well upon discovering a positive result (presence) for total coliform. If the re-test also indicates a positive, as of 2016 the MDH will perform a site investigation.

Nitrate

The Forest collects and provides annual samples for nitrite to the MDH for testing.

Results

Total coliform

Between 2005 and 2015, the SNF analyzed 3,188 drinking water samples (including repeat tests), for an average of 319 samples per year. Approximately 30 samples per year (between 2012 and 2015) indicate the presence of total coliform (or about 10 percent of the average number of annual tests between 2005 and 2015). As noted above, a test results indicating presence dictates a repeat sample, potential treatment, and site investigation. The results of the analyses are stored in the USFS INFRA database.

Nitrate

The drinking water standard for nitrate concentration is 10 mg/l. There are no known exceedances of this standard on the SNF. Figure 5.14-10 shows a summary of the results.

Discussion

Based upon the results of the drinking water effectiveness monitoring, the SNF is providing adequate protection to the public.

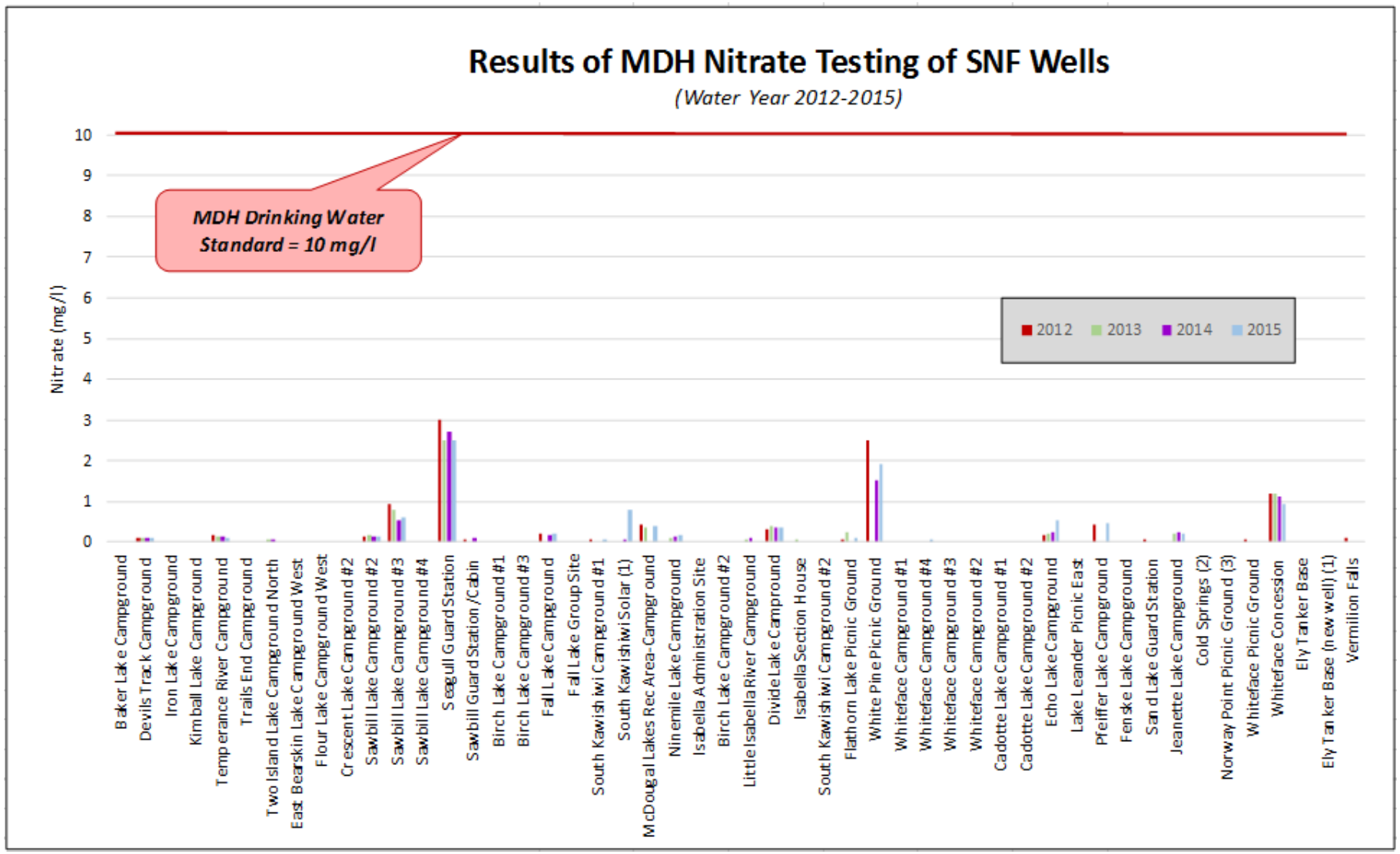


Figure 5.14-10. Summary of nitrite sampling of SNF water wells (2012-2015)

5.14.3 – Water Resources – Swimming Beaches

The Superior National Forest (SNF) monitors beach water quality for the protection of SNF users. The SNF has monitored posted swimming beaches for fecal coliform bacteria. Fecal coliform bacteria can enter water bodies through direct discharge of waste from mammals, birds, agricultural and stormwater runoff, and from human sewage. The State nor the EPA requires this testing; however, but the Forest Plan directs monitoring every five years. The Superior has collected data 10 managed beaches. In 2010, the Forest reduced testing to three lakes (Leander, McDougal, and Whiteface) because Pfeiffer Lake beach use is relatively low and the lack of e-coli presence in seven of the lakes.

5.14.3.1 Swimming Beaches Monitoring Question

Does water in the Superior (drinking water sources and swimming beaches) meet standards of quality protective of human health and aesthetics?

Last Updated

The 2004 Forest Plan presented this monitoring question and carried it through the 2016 administrative change to Forest Plan Chapter 4-Monitoring and Evaluation.

Monitoring Indicator(s)

The Forest addresses this monitoring question by evaluating whether drinking water in SNF campgrounds and facilities are consistent with the Forest Plan objectives summarized below.

Objective. O-PH-4. Forest owned facilities and designated recreation sites and/or natural resource amenities are inspected and managed to ensure safe operation**.**

The indicator of effectiveness is the compliance with the Environmental Protection Agency (EPA) beach action value (BAV).

Monitoring Frequency

Swimming beaches monitoring occurs once a month during the open water-swimming season considered between Memorial Day and Labor Day.

Background & Driver(s)

Superior staff collect samples and analyze them at the SNF water lab.

Prior to 2004 - Membrane:

In 2003, the SNF employed the membrane method of bacterial assessment, a procedure that splits a sample to facilitate multiple fermentation (MF), in a substrate containing 4-metylumbelliferyl-β-D-glucuonide (MUG). The method requires incubating the sample and counting the number of colonies identified after a day. Both beach testing and potable water supply testing used this method.

2004-2007 - Colilert:

In 2004, the Colilert method replaced the membrane method. The Colilert method consists of combining a sample with a reagent, incubating the sample for 24 hours, and visually comparing the sample's color and regent with a standard. The test yields a result of total coliform and E. coli presence. The method was less labor intensive and less costly than the membrane method, but it did not allow for quantification of the bacterial presence. The EPA has directed use of counted E. coli colonies as the preferred analytical and management practice.

2007-2016 – Coliscan:

In response to EPA general direction, the SNF replaced the Colilert method with the Coliscan method for analyzing beach samples. The Colilert method consists of combining a gel and a small amount of the water sample, then incubating the gel and sample overnight on a petri dish. Coliscan results are in the form of counted E. coli colonies, which are directly comparable to EPA "Beach Action Value" (BAV) standard.

Sample Sites:

Beach testing have varied over the years based upon the history of testing results and beach management. Figure 5.14-11 provides a map of the sites.

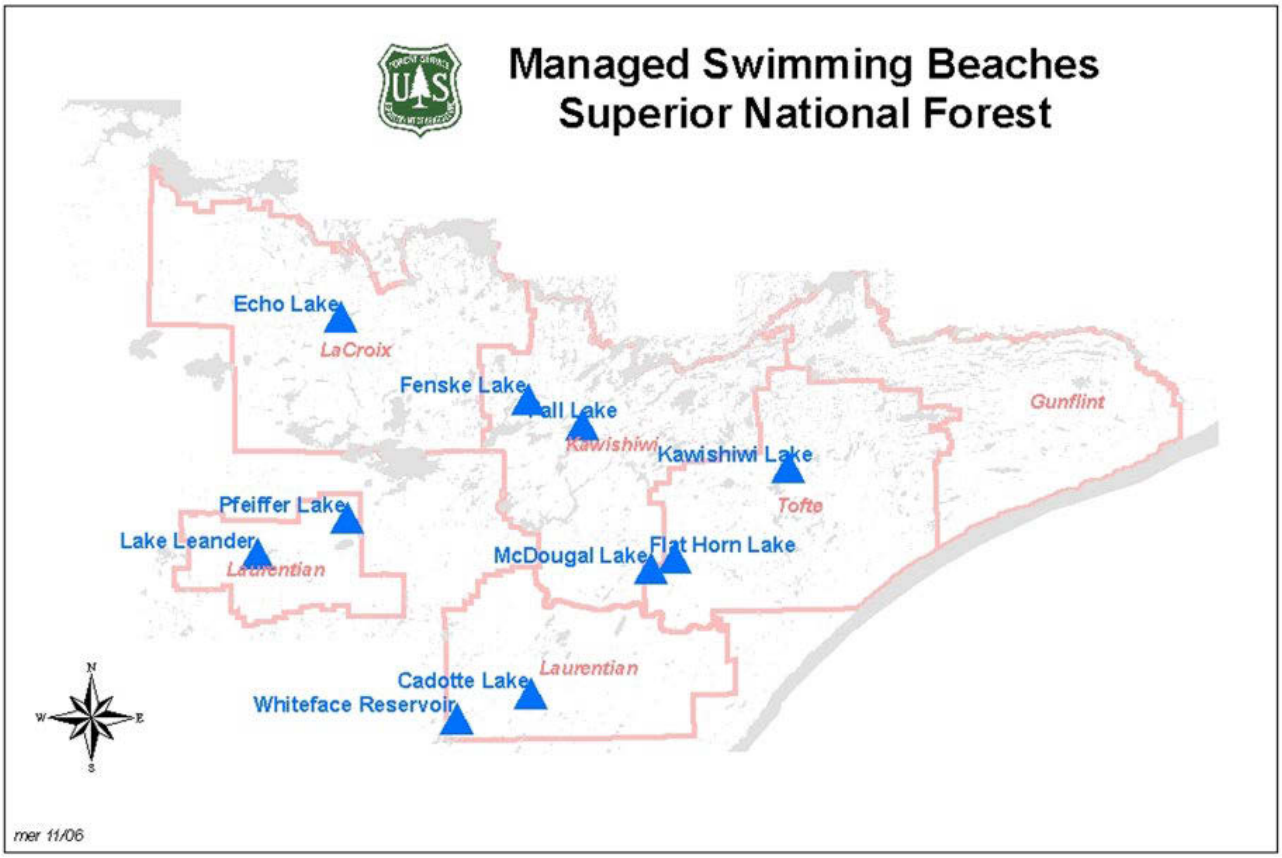


Figure 5.14-11. SNF beach water quality monitoring sites (2007-2016)

Results

Beach water quality monitoring results are located in the following tables 5.14-3 and 5.14-4. T

Table 5.14-3. Summary of SNF beach water quality testing

SNF Beach Water Quality Testing Results (2007-2016)											
Total Number of Sample Dates = 53											
	Cadotte Lake	Echo Lake	Fall Lake	Fenske Lake	Flathorn Lake	Lake Leander	McDougal Lake	Pfeifer Lake	South Kawishiwi	Whiteface Reservoir	TOTAL
Total Number of Non-Detects	11	9	13	13	9	39	31	8	11	36	180
Total Number > 0 Results	0	1	1	0	1	7	8	1	2	7	28
Total Number of Samples Taken	11	10	14	13	10	46	39	9	13	43	208
% Times Sampled	21%	19%	26%	25%	19%	87%	74%	17%	25%	81%	
% Non-Detects	100%	90%	93%	100%	90%	85%	79%	89%	85%	84%	87%
Maximim (cfu / 100 ml water)	0	1	10	0	40	100	133	20	80	330	*330*
Number of Exceedences	0	0	0	0	0	1	3	0	0	1	5

Table 5.14-4. SNF beach water quality testing data (2007-2016)

SNF Beach Water Quality Testing Results

e. coli colony forming units (cfu)/100 mL water

Sample Date	Cadotte Lake	Echo Lake	Fall Lake	Fenske Lake	Flathorn Lake	Lake Leander	McDougal Lake	Pfeifer Lake	So. Kawishiwi	Whiteface Reservoir
6/26/2007	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
6/28/2007	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA
7/3/2007	NA	NA	10	ND	40	100	ND	ND	ND	NA
7/17/2007	NA	NA	NA	ND	NA	ND	NA	NA	NA	NA
7/24/2007	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA
7/26/2007	ND	NA	ND	NA	ND	NA	10	NA	NA	330
8/3/2007	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
9/4/2007	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA
6/4/2008	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
6/11/2008	ND	1	ND	ND	ND	ND	ND	ND	ND	ND
6/16/2008	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
6/25/2008	NA	NA	NA	NA	NA	ND	NA	NA	NA	ND
6/26/2008	NA	NA	ND	ND	ND	NA	ND	NA	ND	NA
7/2/2008	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
7/7/2008	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
7/9/2008	NA	NA	NA	NA	NA	60	NA	20	NA	ND
7/28/2008	NA	ND	ND	ND	NA	ND	NA	NA	ND	NA
7/29/2008	ND	NA	NA	NA	ND	NA	ND	NA	NA	ND
7/30/2008	NA	NA	NA	NA	NA	20	NA	ND	NA	NA
8/2/2008	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
8/4/2008	NA	ND	NA	NA	ND	NA	NA	NA	NA	ND
8/12/2008	ND	NA	ND	ND	NA	NA	NA	ND	ND	NA
6/17/2009	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
7/8/2009	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
8/28/2009	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
6/10/2010	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
6/17/2010	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
6/25/2010	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
7/7/2010	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
7/15/2010	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
7/23/2010	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
8/6/2010	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
8/11/2010	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
5/23/2011	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
6/27/2011	NA	NA	NA	NA	NA	33	ND	NA	NA	ND
7/28/2011	NA	NA	NA	NA	NA	ND	67	NA	NA	ND
8/29/2011	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
6/11/2012	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
7/30/2012	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
9/10/2012	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
6/12/2013	NA	NA	NA	NA	NA	ND	33	NA	NA	ND
7/10/2013	NA	NA	NA	NA	NA	ND	133	NA	NA	ND
9/5/2013	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
6/25/2014	NA	NA	NA	NA	NA	67	ND	NA	NA	33
7/21/2014	NA	NA	NA	NA	NA	ND	ND	NA	NA	ND
8/20/2014	NA	NA	NA	NA	NA	33	100	NA	NA	66
6/10/2015	NA	NA	NA	NA	NA	ND	ND	NA	NA	67
7/6/2015	NA	NA	NA	NA	NA	ND	100	NA	NA	ND
8/10/2015	NA	NA	NA	NA	NA	ND	67	NA	NA	33
6/6/2016	NA	NA	NA	NA	NA	ND	20	NA	NA	ND
7/6/2016	ND	ND	ND	ND	NA	40	NA	ND	ND	ND
8/2/2016	ND	ND	ND	ND	NA	ND	NA	ND	20	40
8/24/2016	ND	ND	ND	ND	NA	ND	NA	ND	80	20

Standard: Recreational Water Quality Criteria, U.S. Environmental Protection Agency, 2012. Estimated Illness Rate: 32 per 1,000 primary contact recreators

Notes:

##	= colony forming units per 100 mL – meeting standard water below 100 cfu / 100 ml
##	= exceeding **geometric mean (5 samples in 30 days) standard of 100 cfu / 100 ml**
##	= exceeding **single sample standard of 190 cfu / 100 ml**
ND	= analyzed but not detected
NA	= not analyzed

Discussion

Based upon the results of the drinking water effectiveness monitoring, the SNF is providing adequate protection to the public. Beach water quality samples were not collected at Flathorn Lake and McDougal Lake in 2016 because Flathorn Lake is no longer managed as a swimming beach and McDougal Lake sit is not practically managed for swimming due to emergent plants such as wild rice in the 'swimming beach' area.

As noted above in table 5.14-3, nearly 90 percent of the tests *did not detect any e-coli* in the water and about 98 percent of the samples did not exceed the beach action value. Three of the five values that exceeded were *at* the lower geometric mean threshold of 100 cfu/100mL.

A single sample exceeded the lower geometric mean threshold in 2013 but did not exceed the single sample threshold.

There has only been one (1) instance when the tests have exceeded the single sample standard to dictate temporarily closing a beach. Follow-up testing indicated a *non-detect* for e-coli. This suggests a potential issue with the water sample collection or an anomalous condition.

Recommendations

The results of beach testing between 2007 and 2016 indicates that SNF beaches consistently meet health standards and have very good water quality. Based upon this understanding, there is little benefit to the public to continue annual beach water quality testing. The Forest proposes considering the elimination of the beach water testing.

5.14.4 "Sixty Percent" Analysis

Research from upper Midwestern forests identified a watershed-based water yield threshold using the area of newly cut or non-forested ("open") upland or upland with "young" trees (under 16 years of age) (Verry, 1986). When the amount of young and open upland is greater than 60 percent of the total 6th-order watershed area, that watershed identifies at risk for increased peak-water runoff discharge, which may have effects on fluvial geomorphology, overland and in-channel sediment transport, water quality, and aquatic habitat. The 60 percent threshold identified above is included in the Superior National Forest (SNF) Land and Resource Management Plan (LRMP) as S-WS-1 (U.S. Forest Service Eastern Region 2004).

S-WS-1: Management actions on National Forest System (NFS) land will not increase the total (all ownerships) acreage of upland young forest (less than16 years), and upland openings to the point where the combined acreage exceeds 60 percent of the total area of any 6th-level watershed.

National Environmental Policy Act documents routinely use the 60 percent analysis as a cumulative (watershed-scale) indicator. The MN DNR also applies the 60 percent threshold identified in Verry (1986) as a rule-of-thumb.

5.14.4.1 "Sixty Percent" Monitoring Question

To what extent is Forest management affecting water quality, quantity, flow timing and the physical features of aquatic, riparian, or wetland ecosystems? (LRMP p. 4-13)

The last formal written discussion for this monitoring question was in the 2009 SNF monitoring report.

Monitoring Indicator

Verry (1986) describes the 60 percent young and open upland.

Monitoring Frequency

The Forest calculates the 60 percent analysis on a Forest-wide basis as needed, generally every other year. On occasion, vegetation management or other landscape-level management projects calculate it on an as-needed basis.

Background & Driver(s)

As stewards of the Forest's water resources, SNF hydrologists' evaluate for potential effects of management activities to hydrologic systems and identify options to minimize or avoid adverse effects. The Superior's deciding officials receiving the effects analysis and recommendations make management decisions for the resource. Applied research, such as the work by E.S. Verry noted above, provides a means to assess the risk to water resources. The SNF LRMP desired conditions related to this indicator include:

- Water quality, altered stream flow, and channel stability do not limit aquatic biota or associated recreational uses. Water in lakes, streams, and wetlands meets or exceeds State water quality requirements. (D-WS-5, p.2-10)
- Watersheds provide an appropriate quantity, quality, and timing of water flow. Stream channels and lakeshores are stable… Management activities protect or promote quality of habitats that occur in the riffle areas of streams, improving stable channel characteristics. (D-WS-6, pp. 2-10 – 2-11)

The monitoring question ensures the evaluation of any impacts associated with management activities to water resources. The analysis addresses 36 CFR 219.12 (a)(5)(i) - status of select watershed conditions – and 36 CFR 219.12 (a)(5)(vii) – progress toward meeting the desired conditions and objectives in the plan, including providing for multiple use opportunities.

Methods

In accordance with the LRMP, Forest staff conduct the 60 percent analysis on sixth-level watersheds as delineated in the National Hydrography Dataset, the standard watershed delineation used on national forests. Sixth-level watersheds are typically between 10,000 and 80,000 acres in area. The Forest identified 218 sixth-level watersheds that intersect the SNF proclamation boundary and extend across portions of Koochiching, Itasca, St. Louis, Lake and Cook Counties in Minnesota and into Ontario, Canada.

The LRMP notes that "open" areas are to include permanent openings, roads and associated clearings, parking lots, cropland, pastures, borrow pits, utility rights-of-way, town sites, homes and yards, and upland brush, and grass. Open area extent is developed using a varied suite of spatial data from SNF, State, county, and Canadian sources: roads, trails, utility corridors, and railways; land use data (raster dataset); fire history; timber harvest history from federal, State, and county sources; blowdown areas; and ecological landtype (soils) data. A dataset referred to as "change detection" identifies new young areas on private lands, which the State of Minnesota developed; aerial photos are reviewed year over year to identify areas that have been harvested or otherwise experienced a stand reset.

Wetland is a natural sponge and acts to slow down water, reduce erosion, and promote water infiltration; it inhibits sediment and nutrient transport to streams and lakes in a wide variety of harvest conditions. Hence, for this analysis, the age of vegetation within a wetland is considered inconsequential and is not part of the "young or open" computation. The National Wetland Inventory, updated in 2014, assesses wetland extent by watershed. Data used in the analysis are the best available but are acknowledged incomplete. For example, Cook County, Minnesota does not track age information on county-owned timber; Ontario data managers have not mapped wetland resources; blowdown mapping across the SNF is limited; change detection data from 2015, 2017, and 2018 are not available. Some variability in results are expected, even in largely unmanaged watersheds, may be expected as information and maps are updated or improved.

The presence of certain characteristics may create conditions under which exceedance of the 60 percent threshold is not mathematically possible on a watershed basis. Factors may be artifacts of the analysis method or simply exclusionary elements based on reasonable *de minimus* criteria. A first-pass analysis to evaluate each watershed's unique characteristics related to these exclusionary elements focused on five components:

- **Wetland.** The Superior does not consider wetland a "young" or "open" upland regardless of the state of vegetation on it. Therefore, for watersheds with more than 40 percent wetland, less than 60 percent of the watershed is available as potential young or open upland.
- **Boundary Waters Canoe Area Wilderness (BWCAW), Quetico Provincial Park, and Voyageurs National Park**. Wilderness areas and parks are unaltered, unmanaged swaths of land where the hydrologic cycle interacts with the landscape free from modification associated with anthropogenic activity. Precipitation, runoff, infiltration, streamflow, storage, and evaporation are expected to occur at rates and similarities of pristine watershed condition. Areas of natural vegetative openings in wilderness or parks are placed in this pristine watershed context, because the analysis of the entire area in a wilderness or park is counted as "old." Therefore, for watersheds with greater than 40 percent area within wilderness or park, less than 60 percent of the watershed is available as potential young or open upland.
- **Combination of wetland and wilderness or park area.** Where more than zero but less than 40 percent of a watershed's total area lies within the BWCAW or a park, the wetland area outside the BWCAW or park was also calculated. For some, the park area plus the area of wetland outside the park or wilderness was greater than 40 percent, leaving less than 60 percent as potential young or open upland.
- **Percent intersecting the SNF.** A number of watersheds intersected the SNF proclamation boundary but only very minimally. Thus, the Forest uses an exclusion threshold of three percent; if less than three percent of a watershed was inside the SNF boundary, further analysis excludes it based on the likely *de minimus* effect of SNF management activities on that watershed.
- **Percent Federal management.** A number of watersheds intersected the SNF proclamation boundary at more than the three percent minimum described above, but the actual Federal management within the watershed was less than three percent of the watershed area. Based on the likely *de minimus* effect of SNF management activities on that watershed, it was excluded from further review. Watershed (excluded on a percent ownership basis) reviews

should be part of future analyses to ensure ownership characteristics within that watershed have not changed over time.

Using these criteria, the Forest excluded over half of all watersheds intersecting the SNF boundary from further analysis. Future natural disturbances such as fire or blowdown within the watersheds dominated by the BWCAW or parks would warrant future evaluation. The SNF Monitoring Report project file lists the watersheds eliminated from additional analysis based upon existing conditions (figure 12).

Results

The Superior used two parts to complete the evaluation of the monitoring indicator. The exclusion analysis uses the criteria outlined above to identify watersheds that will not exceed the threshold, and therefore do not require full analysis. Watersheds not identified in the exclusion analysis – that is, watersheds where management activities may have a role in exceedance of the 60 percent threshold – were analyzed for the existing condition of percent young and open upland as described in the LRMP.

Exclusion analysis

As previously noted, 218 watersheds intersect the SNF. Based on the exclusion criteria above, 122 of those watersheds were eliminated from additional analysis (figure 5.14-12). The dominant criteria for exclusion was the presence of watershed area in the BWCAW or park (figure 5.14-12). Wetlands were of secondary importance, with *de minimus* criteria resulting in the fewest exclusions. Twenty-five watersheds qualified for exclusion under more than one criterion. Assuming watershed boundary delineations do not change, ownership distribution remains constant, and there are no natural disturbances within the watershed, these 122 watersheds can also be eliminated from future project-level analysis.

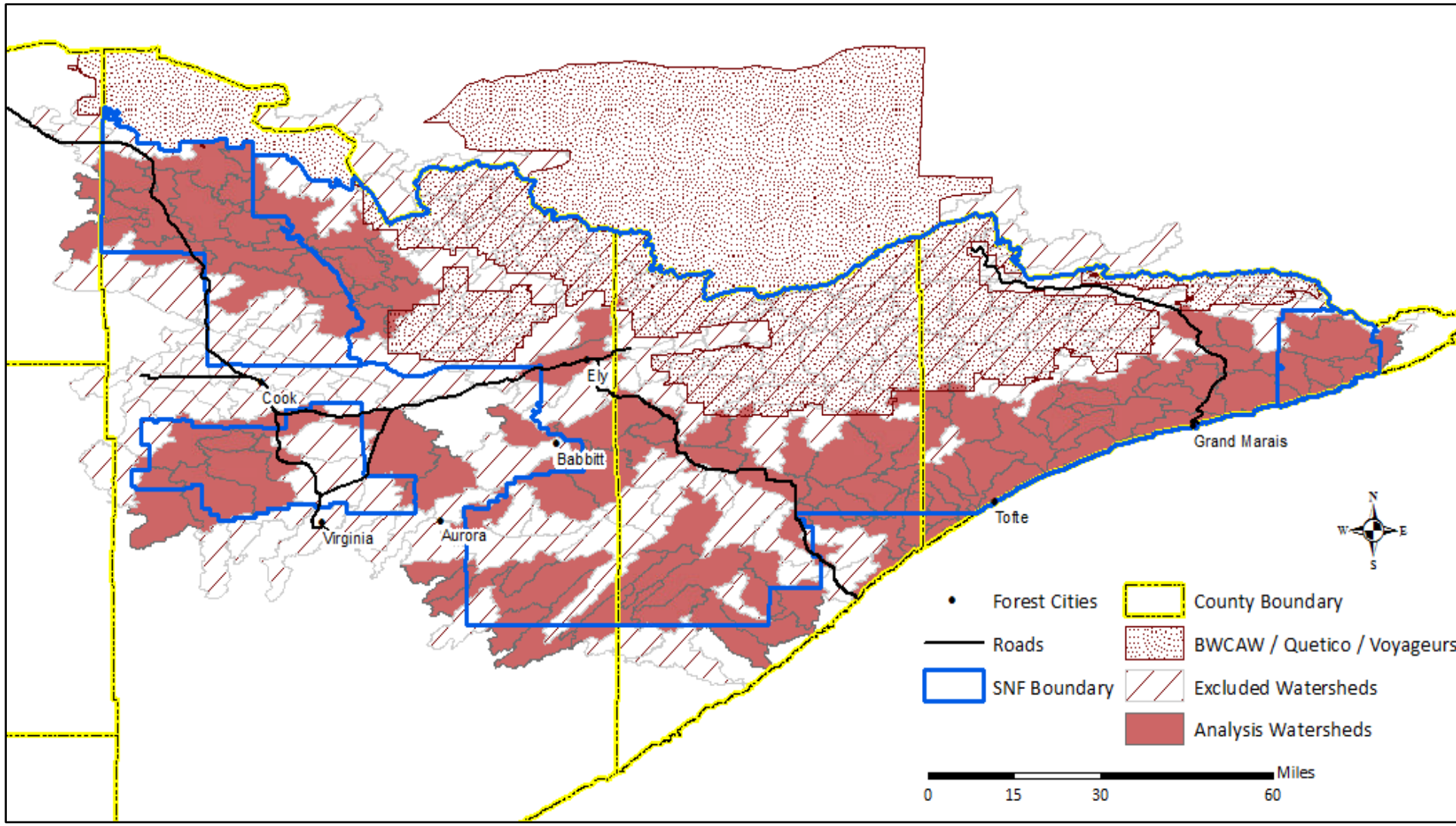


Figure 5.14-12. Forest-wide excluded and analysis watersheds

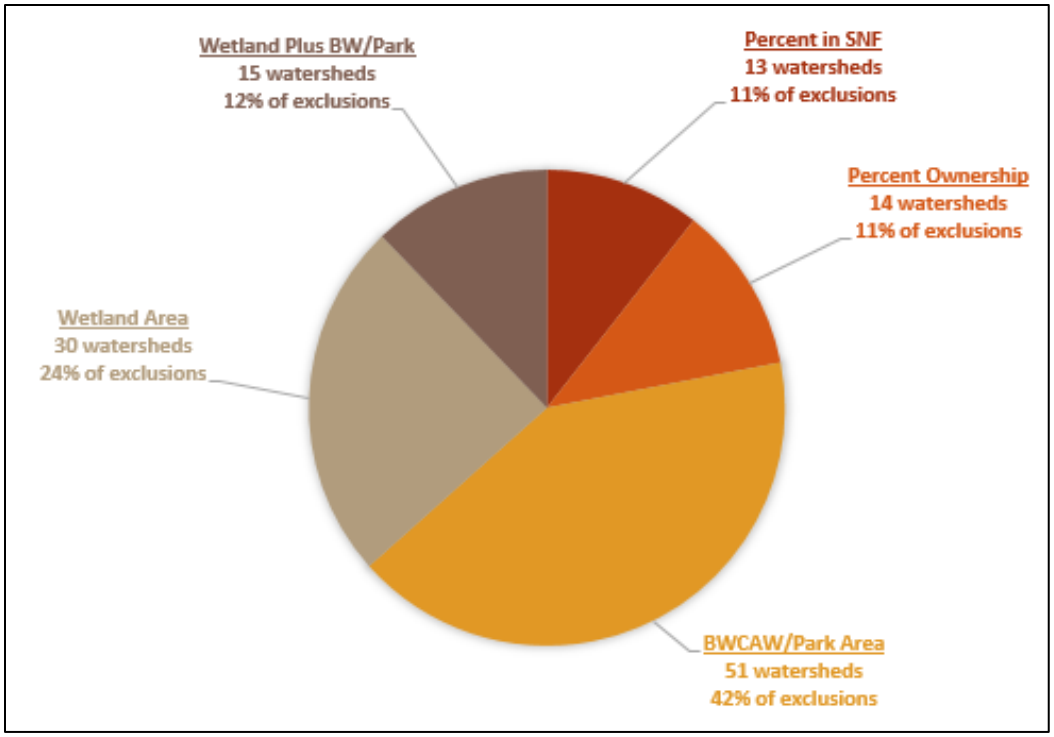


Figure 5.14-13. Frequency of exclusion criteria for 122 "excluded" watersheds

Existing Condition

For the 96 watersheds not mathematically excluded from additional analysis (figure 5.14-12), GIS data were compiled from on-Forest databases, as well as State, county, and Canadian data sources. None of the 96 watersheds (for which the existing condition analysis was conducted) exceeded the 60 percent threshold. The SNF monitoring report project file contains the results for percent young and open upland for these 96 watersheds. Calculated young and open upland values ranged from less than three percent (Heartbreak Creek) to 36 percent (Lost River). Figure 5.14-14 illustrates existing condition young and open upland analysis across the 96 SNF watersheds.

Higher young and open upland percentages are more typical in the SNF's west and northwest (figure 5.14-14). Watersheds in these areas tend to host a greater patchwork of ownerships; federal management is rarely greater than 25 percent. Similarly, the analysis indicated relatively higher (35 percent) young and open upland percent for the Taconite Harbor - Frontal Lake Superior watershed, a watershed that extends along Lake Superior. Just six percent of the Taconite Harbor watershed lies within the SNF boundary, with SNF management responsibility for just four percent of it. The mixed ownership and relatively higher young and open upland area in these watersheds emphasizes the need for partnerships and cross-ownership management. Figure 5.14-15 illustrates the general relationship between young and open upland percent and federal management: with more federal management, the indicator percent tends to be lower; with increased mixed/other (reduced federal) management, indicator percent tends to be higher.

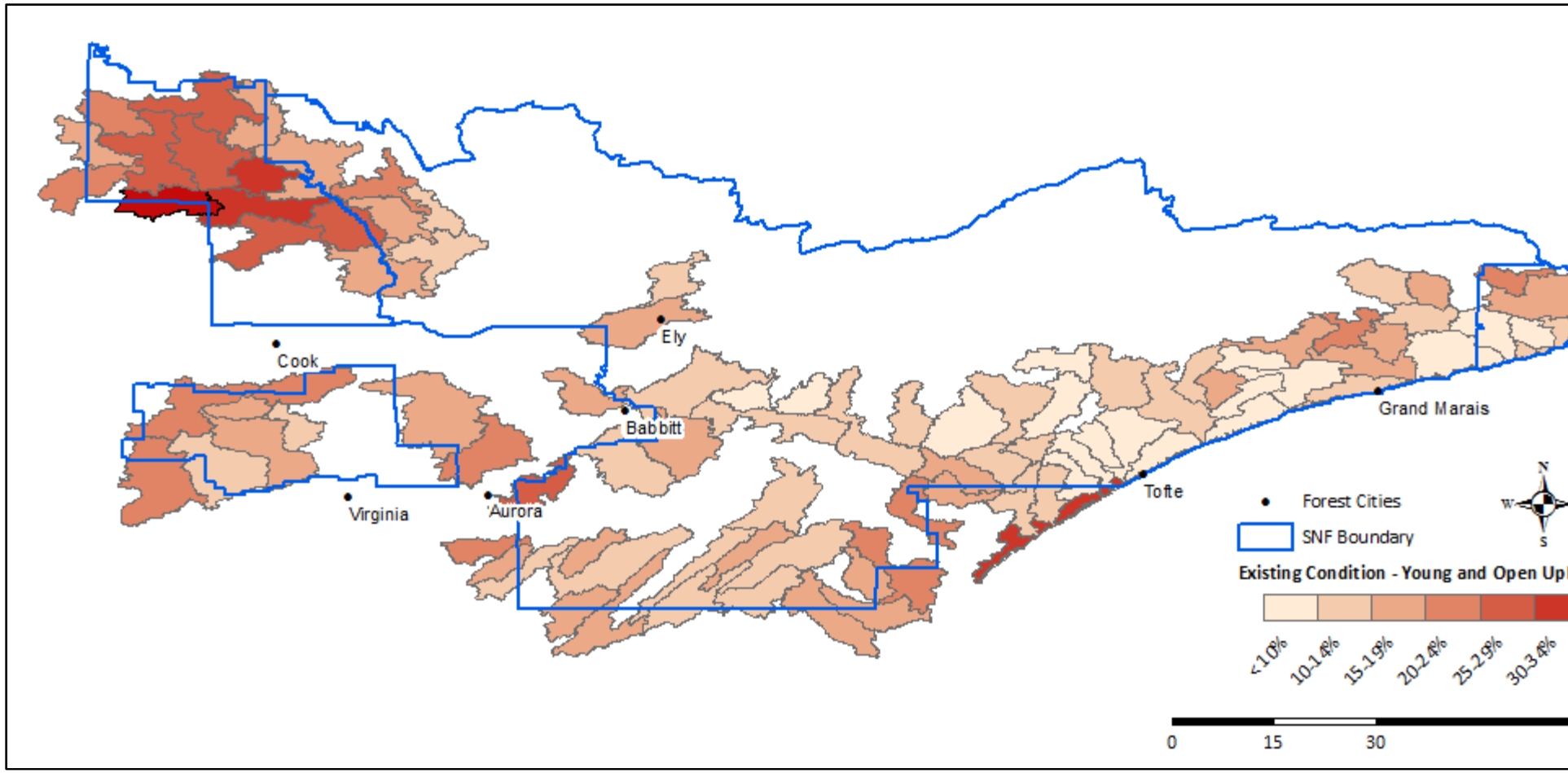


Figure 5.14-14. Existing condition-young and open upland within analysis watersheds

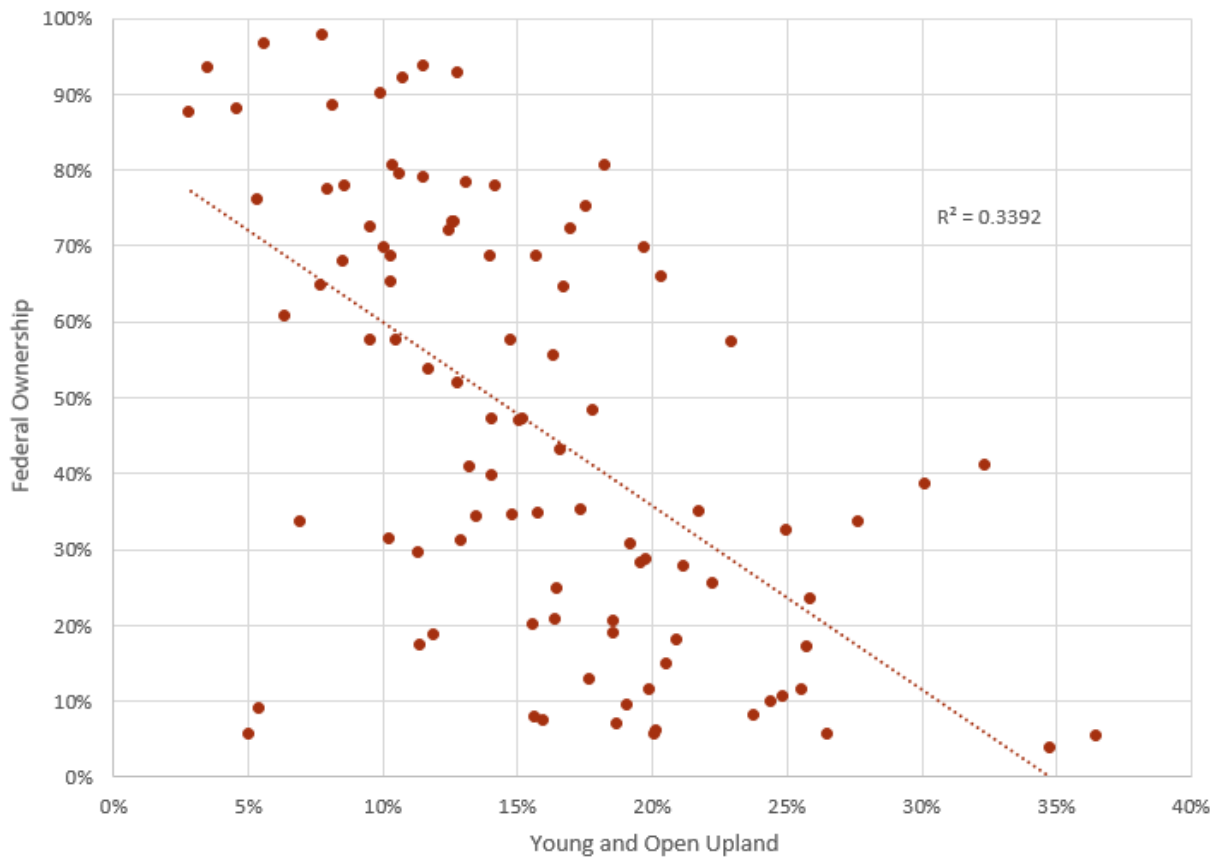


Figure 5.14-15. Young and open upland percent versus federal management for 96 analyzed watersheds

Discussion

The 60 percent analysis is a simple, straightforward evaluation that provides insight into the potential impact of land use on water resources on a watershed scale. Watershed water yield and runoff increases can spiral into other effects to water resources, such as changes in geomorphology, declines in water quality, and reductions in habitat diversity and quality.

Analysis results support the hypothesis that forest management intensity is unlikely to move a watershed into a different flow routing or runoff paradigm, despite some increase to water yield and flow timing from the management activities. If movement to a new flow routing or runoff paradigm occurred, downstream characteristics such as water quality, streamflow, degree of erosion, habitat quality or physical features of aquatic, riparian, or wetland ecosystems would negatively be impacted at the prescribed management scale.

Higher indicator values mostly occurred in watersheds with a significant component of mixed ownerships. The Superior should thoughtfully consider management in these watersheds as creation of substantial young or open upland areas may have already occurred on these other ownerships. Private ownerships are perhaps less likely to consider the watershed-scale consequences of their activities. The “all-lands” Arrowhead Landscape Project proposed for the northwestern SNF area may be one way to ensure that all landowners consider the overall impact of their activities, and that SNF hydrology staff are aware of planned activities.

Certain watersheds with relatively higher percent young and open upland also coincide with watersheds hosting as federally impaired streams. Such watersheds (table 5.14-5) also warrant careful management using a multiple-ownership approach. While the cause of the listing is typically attributed to non-forestry sources (e.g., mining tailings basins, atmospheric deposition), improper forestry practices have driven change to total suspended solids and mercury in water resources, among other parameters. Thus, evaluating the full scope of activities in a watershed and considering the importance of managing forestry practices may help to assist in the de-listing of these resources.

Table 5.14-5. Watersheds greater than 25 percent young and open upland that also host federally impaired streams

Watershed	HUC ID	Federal Listing	Young/Open Upland (%)
Black Duck River	090300012402	Total suspended solids, E. coli	27.7
Lower Ash River	090300012403	Total suspended solids	26.5
Kjostad Lake – Vermilion River	090300020503	Mercury in fish	25.8
Partridge River	040102010105	Mercury in fish, mercury in water	25.6

The 60 percent indicator is a basic analysis that addresses the effect of management activities on the landscape. The SNF implements the indicator as a "one-size-fits-all" solution for watersheds across the SNF. No adjustments for potentially important watershed variability that exists, for example, from relatively low-relief watersheds near Ely and in the Vermilion River basin, to the more steeply sloped watersheds in the Lake Superior basin, or variability in soil permeability and thickness, occurs.

The range of results identified, which are similar to previous rounds of this analysis run for the Forest, indicate watersheds on the SNF are not at risk of exceedance for this indicator.

Conformance with Forest Plan direction remains high. Watersheds generally are not at risk of exceeding the threshold, pending a catastrophic reset event like a large fire or varied owner groups working in the same watershed at the same time.

5.14.5 Aquatic Species

Biotic integrity is defined as, "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region" (Karr & Dudley, 1981). This section discusses to the biological integrity of lakes and streams with the following questions.

5.14.5.1 Aquatic Species Monitoring Question

- *To what extent is Forest management providing ecological conditions to maintain viable populations of native and desired non-native species?*

- *To what extent is Forest management contributing to the conservation of sensitive species and moving toward short term (10-20 years) and long-term (100 years) objectives for their habitat conditions and population trends?*
- *To what extent is the Forest Service cooperating with the State and Tribes on inventories and assessments?*

Monitoring Indicator(s)

Forest staff have collected aquatic community data at reference sites for multiple years. Reference sites represent the range of streams and management activities of the Forest. In addition, the Forest cooperatively share those data with Minnesota Pollution Control Agency (MNPCA) and record the data in the statewide biological monitoring database. The Forest uses data from hundreds of additional sites evaluated by MNPCA to provide a context for aquatic biological community health.

Change in fish and macroinvertebrate community MNPCA index of biological integrity (IBI), diversity, and similarity measures at sites between sample periods. The Forest uses data from hundreds of additional sites evaluated by MNPCA using the same methods and timeframes to provide a context for aquatic biological community health.

Monitoring Frequency

Staff typically visit the reference sites every two years, depending upon available resources and management activity in the contributing watershed.

Background Drivers

Changes in fish and macroinvertebrate community measured by IBI, diversity, and similarity between years at identical sites can indicate changes in the larger aquatic community. These changes may be due to natural or anthropogenic stressors. By using a series of reference sites with and without adjacent forest management activities, natural variability can be separated from changes due to impacts from forest management activities.

The Clean Water Act (P.L. 92-500) and SNF LRMP desired conditions drives the related to this indicator, including:

- Aquatic… habitats and species populations… are present in amounts, quality, distributions, and patterns… (D-WL-3) Aquatic… habitats and species populations… are present in amounts, quality, distributions, and patterns… (D-WL-3)
- Provide ecological conditions to sustain viable populations…(O-WL-1)
- Move… aquatic habitats in the direction of desired conditions…(O-WL-2)
- Provide an adequate and representative array of habitat conditions for the desired… species…(O-WL-3)
- Maintain, protect, or improve habitat for sensitive species…(O-WL-18)
- In all known sites and breeding locations, enhance, or restore high quality habitat for these species primarily by implementing management direction that promotes desired

conditions for healthy and functional watersheds, riparian areas, and vegetation. (O-WL-28)

- …sensitive aquatic species will provide priority areas for proactive management to improve habitats. (O-WL-29)
- (MIH 14) Maintain and improve lake and stream habitat quality. CFR 219.19(6) (O-WL-36)

Method(s)

The Superior established stream monitoring reaches to evaluate the effects of forest management activities on biologic features of aquatic ecosystems. Since 2005, there have been 31 reference reaches established and measured to represent a range of stream conditions found on the Superior National Forest. These reach locations also represent varying degrees of adjacent management based on specific projects and proposed actions. At present, 20 reference reaches have sufficient data to warrant analysis based on number of measurements (three years of data within a five-year period). These sites include those with no adjacent management activity and others that include adjacent harvest. For sites with adjacent harvest activity, Forest staff analyzed both pre-treatment and post-treatment data. Additionally, Forest staff collected fish community data at each reference site using single pass electrofishing. Analysis of the fish community included measures of indexes of biological integrity (IBIs), diversity, and statistical analysis (ordination) using the species matrixes (type and relative abundance of fish species) at each site and for each year of sampling. Each site during each sampling even had similar timing and sampling efforts. Some sites followed the multi-habitat composite sample methods established by the Minnesota Pollution Control Agency (MPCA) gathering additional data for macroinvertebrate communities. The Forest Service joined with other agencies for sites evaluating using a database of approximately 280 MPCA stream monitoring sites within the Forest boundary. Figure 5.14-16 displays an example of an aquatic monitoring site. The red polygons within the figure are harvested timber units, and the reference reach extends between the green and red dots on Hill Creek (which is flowing to the northwest).

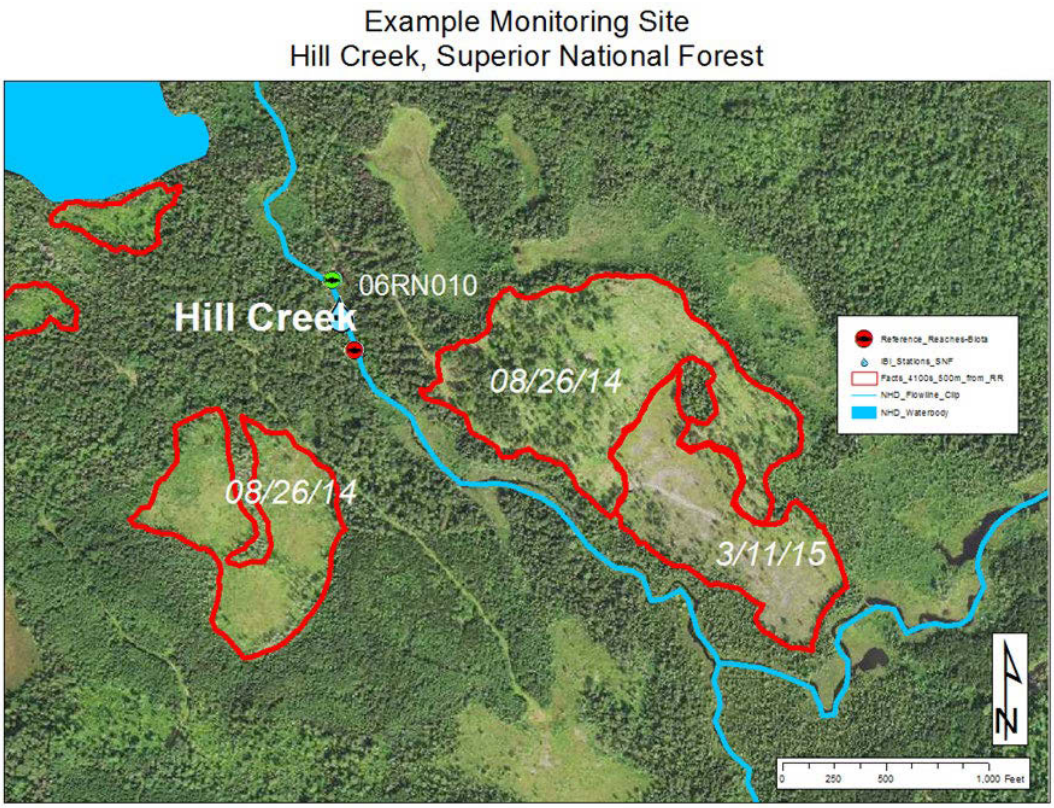


Figure 5.14-16. Example of aquatic monitoring site

Results

Fish diversity and community similarities for the reference reaches suggest no significant shift in community structure between years at any of the sites. Sites differing from each other used statistical similarities and ordinations of each site and each year of sampling. Similarity was generally higher among sampling years at the same site rather than between different sites. Samples with higher numbers of species and abundances (generally warm- or cool-water fish communities) had higher similarities than sites with fewer species and abundances (cold-water communities). Data also showed that the catch per unit efforts are similar at sites between years for most fish species. Species present at a site in one year, and absent in the other years have low relative abundance and low detection rates (low catch per unit effort), indicating that these species are subject to greater sampling variability. Overall, these sites represent the range of species expected in wadeable streams on the SNF. At locations where forest management had occurred, IBI scores for both fish and macroinvertebrates at sites were within the range of natural variability. Sites not adjacent to forest management show similar ranges in IBI scores for both fish and invertebrates.

Discussion

Collectively, these sites indicate that the Superior National Forest has a high level of biological integrity for both fish and invertebrate communities. In addition, lake-monitoring sites established for water quality and fisheries assessments by the Minnesota Department of Natural Resources (MnDNR) indicate that lake communities are biologically healthy. It is important to

continue to monitor the biological attributes of aquatic systems to evaluate the variability and biological integrity of the resource. In addition, as some watersheds have now had some logging activity, continued monitoring will allow a departure analysis to occur over the next several years.

The results of this analysis indicate the forest management activities of the SNF do not degrade biological integrity of aquatic resources on the SNF.

Water Resources Recommendations

Water Quality Recommendations

- The SNF should continue to collect water quality data as appropriate and support the MPCA and others in their collection and analysis of water quality data.
- There is no proposed enhancement of the evaluation methodology.

Drinking Water Recommendations

- The SNF recommends continuing the existing program to analyze and treat drinking water wells on the SNF.
- There are no recommendations to improve the monitoring of drinking water on the SNF.

"Sixty Percent" Recommendations

- Assuming that watershed boundary delineations do not change, there are no natural disturbances within the individual watershed, and ownership distribution remains constant. Thus, the Forest can eliminate the 122 watersheds identified as part of the exclusion analysis from future project-level analysis.
- Implement proposed 'all-lands management' approach in the Arrowhead Landscape Project on northwestern SNF watersheds to minimize cumulative watershed impact and encourage common management objectives and standards.
- Continue to encourage the 'all-lands management' approach in watersheds with federal stream impairment listings.
- Continue to consider the acquisition of change detection data to assess changes on private ownerships as a priority.
- Continue and standardize the 60-percent analysis technique to compare year-over-year results.
- Utilize the 60-percent analysis to evaluate potential over-use of resources on a watershed basis. However, hydrology staff should assist as needed to identify situations at smaller scales that may be problematic in spite of the indicator's results.

Aquatic Species Recommendations

- Continue monitoring to allow a stronger departure analysis to occur as more sites have adjacent management and more post-treatment sampling events. The results of this

departure analysis will help discern whether the implementation of Forest Plan management strategies is adequately protecting aquatic and water resources.

Water Resources References

Karr, J. R., & Dudley, D. R. (1981). Ecological Perspective on Water Quality Goals. *Environmental Mangement, Vol 5, No. 1*, 55-68.

Minnesota Pollution Control Agency (MPCA). (1917). *Rainy River-Headwaters Watershed Monitoring and Assessment Report.* St. Paul: MPCA.

Minnesota Pollution Control Agency (MPCA). (2014). *Lake Superior - South Watershed Monitoring and Assessment Report.* St. Paul: MPCA.

Minnesota Pollution Control Agency (MPCA). (2017). *Lake Superior-North Watershed Monitoring and Assessment Report.* St. Paul: MPCA.

Minnesota Pollution Control Agency (MPCA). (2018). *Cloquet River Watershed Monitoring.* St. Paul: MPCA.

Minnesota Pollution Control Agency (MPCA). (2018). *Vermilion River Watershed Monitoring and Assessment Report.* St. Paul: MPCA.

Minnesta Pollution Control (MPCA). (2013). *St. Louis Watershed Monitoring and Assessment Report.* St. Paul: MPCA.

Minnesta Pollution Control Agency (MPCA). (2011). *Little Fork River Watershed Monitoring and Assessment Report.* St. Paul: MPCA.

National Weather Service. (2019, April). *Advanced Hydrologic Prediction Service*. Retrieved from Precipitation: https://water.weather.gov/precip/

U.S. Forest Service Eastern Region. (2004). *Superior National Forest Land and Resources Management Plan.* Washington D.C.: U.S. Department of Agriculture.

Verry, E. S. (1986). Forest Harvesting and Water: the Lakes States Experience. *Water Resources Bulletin 22(6)*, 1039-1047.

5.15 Wildlife

This chapter covers wildlife monitoring results on the Superior National Forest (Superior or Forest) for the first and second decade of the Forest Plan. The following four sections separate the results:

1. Wildlife and their Habitats
2. Management Indicator Species
3. Regional Forester's Sensitive Species (Terrestrial)
4. Federally Threatened/Endangered Species.

All of these sections tier to results in the Vegetation and Spatial Pattern chapter of this report that covers important habitat indicators.

5.15.1 Wildlife and their Habitats

The ecological setting of the Superior National Forest is the Laurentian Mixed Forest Province, a transition zone between the boreal forest and eastern deciduous forest. Forest types include spruce-fir, red and white pine, jack pine, aspen-conifer forest, paper birch, northern hardwoods, and lowland conifer. Numerous lakes, streams, and wetlands cover the landscape. This diversity of habitats leads to high diversity in mammal and bird species. For example, the Superior's home to over 155 breeding bird species – the highest of any national forest in the United States.

This section provides an overview of general monitoring of wildlife and their habitats on the Superior. The remaining three sections cover monitoring where there are species-specific mandates for monitoring including: management indicator species (MIS), regional forester's sensitive species (RFSS), and federally threatened and endangered species (TE). Most wildlife species on the Forest do not fall into one of these groups but their conservation is equally important; this section covers those species habitats. The National Forest Management Act and Forest Plan objectives direct the Forest to "sustain viable populations of native and desired non-native species." The following report summarizes ongoing Forest monitoring to track on the general health of forest wildlife populations.

5.15.1.1 Wildlife and their Habitats Monitoring Questions:

- How close are projected outputs and services to actual?
- To what extent is Forest management providing ecological conditions to maintain viable populations of native and desired non-native species?
- To what extent is Forest management moving toward short term (10-20 years) and long-term (100 years) objectives for habitat conditions for species associated with MIH?

How close are projected outputs and services to actual?

The Forest Plan appendix d identifies proposed forest management activities that would work towards the desired conditions identified in the Plan. For wildlife habitat restoration, the Plan predicted conducting 40-50 projects for wildlife habitat improvement in the first decade of implementation. These would include a wide variety of projects such as wildlife species' restoration, vegetation restoration, non-native invasive species control, and habitat restoration structures. The Forest Plan indicated that project-level planning would determine the need, type, and location of habitat restoration. The Superior National Forest tracks terrestrial habitat

improvement in acres rather than number of projects. Since 2004, the amount of wildlife habitat improvement has varied from a low of 83 acres to a high of 20,006 acres annually with an average of 12,400 acres annually (figure 5.15-1). Projects have included:

- Creating young forest with timber harvest.
- Maintaining and promoting of older forest conditions with timber harvest.
- Prescribed burning with wildlife habitat benefits, and seeding native plants to improve pollinator habitat.
- Treating non-native invasive species.
- Planting trees in riparian areas.
- Seeding, planting, and site prepping with wildlife habitat benefits.
- Restoring oak/blueberry habitat; maintaining impoundments important for waterfowl.
- Installing vent caps on pit toilets to protect cavity-nesting wildlife.
- Installing bat houses.
- Installing bear proof dumpsters at campgrounds.
- Decommissioning un-needed roads.

In 2018, the Forest Service discontinued providing individual forests with a target for wildlife habitat enhancement. Prior to this, the Superior met or exceeded its allotted target in most years.

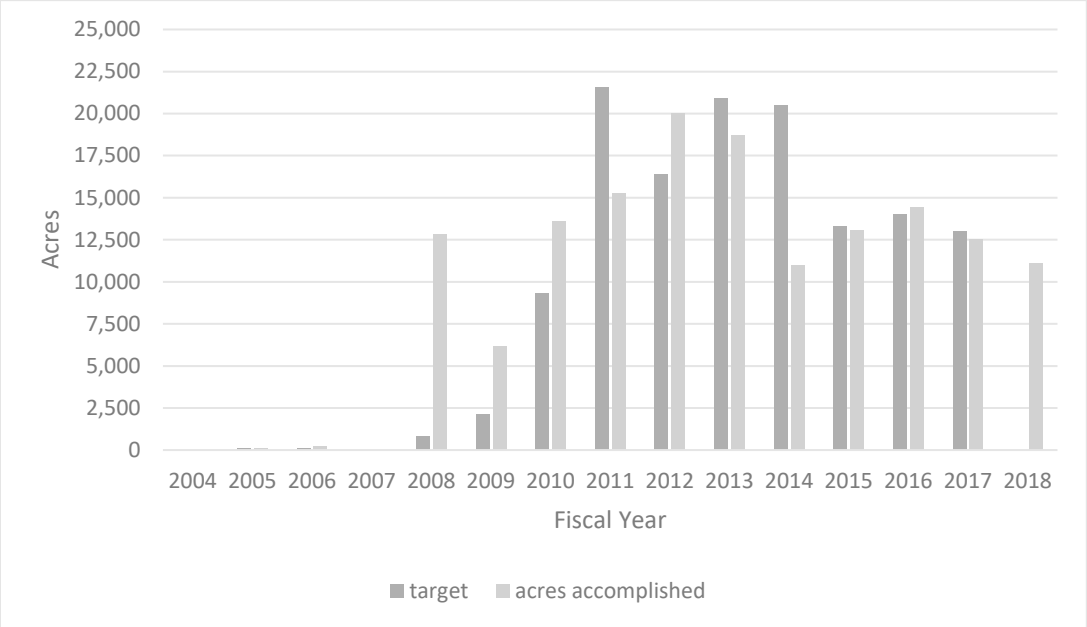


Figure 5.15-1. Accomplishments for terrestrial wildlife habitat enhancement, 2004-2018

- To what extent is Forest management providing ecological conditions to maintain viable populations of native and desired non-native species?

Species Monitoring

The flagship wildlife-monitoring project of the Superior National Forest is "The Western Great Lakes Bird Monitoring Project." This partnership between the Natural Resources Research Institute, the Superior, Chippewa, and the Chequamegon-Nicolet National Forests has established one of the longest-running, large-scale bird population monitoring programs in the Nation, and has advanced the conservation and management of breeding bird species in the western Great Lakes region. With over 500 sample points on the Superior National Forest, 12 habitat types and over 20 years of data, this monitoring program tracks regional population trends and the response of forest birds to regional land use patterns. The data collected through this monitoring effort has resulted in a better understanding of the relationships between birds and habitat management. This monitoring partnership has also resulted in the publication of numerous reports and peer-reviewed journal articles, and informed programmatic and project-level management plans on three national forests.

A general technical report presenting the twenty-plus years of bird monitoring data from 1991 through 2011 was published in 2016 (USDA 2016). This report summarizes a substantial amount of information on population trends, habitat relationships, and bird community assemblages. Factors affecting population trends include discussions on weather, insect outbreaks and timber harvest. Lastly, the report provides management recommendations for eight demonstration species: the olive-sided flycatcher, magnolia warbler, Connecticut warbler, golden-winged warbler, Swainson's thrush, boreal chickadee, scarlet tanager, and yellow-rumped warbler.

The forest bird-monitoring project has demonstrated the importance of long-term studies in tracking population trends. Populations change yearly but results from two decades show increasing or stable populations for most species on the Superior National Forest. Of 64 species tested in 2017, 13 species (20 percent) had increasing trends, 13 species (20 percent) had decreasing trends, and 38 species had non-significant trend indices (Walton et al. 2017). These forest birds represent a variety of different habitats, forest type, and age combinations. Their population's health provides resource specialists with an index on forest health for wildlife in general.

In addition to the long-term forest bird study, tracking yearly changes in other animal species or groups provides a means of evaluating ecological conditions. Table 5.15-1 summarizes some of these annual efforts, the methods, and the partners involved. Other species monitoring that has occurred less often includes winter track and scent post surveys, peregrine falcon breeding occupancy site checks, osprey nest checks, great blue heron nest sites, and marshbird surveys. Table 5.15-1 does not include monitoring of TE, RFSS, or MIS, which other report sections cover.

Table 5.15-1. Ongoing species monitoring on the Superior National Forest (not including monitoring for TE, RFSS, or MIS)

Species/Group	Method	Partner	Number surveys	Comments
Frogs and Toads	Annual listening surveys. 10 stops per route.	MN DNR	7 historical routes – most established in 2000-2001. Only one forest route surveyed in 2018	Coordinated by USGS until 2015 and by MN DNR until 2018. Program under evaluation by DNR
Ruffed Grouse	Annual listening surveys. 10 stops per route	MN DNR	20 routes on the forest. Statewide surveys ongoing since 1950s	Annual report from MN DNR tracks population cycles
Spruce Grouse	Annual fecal pellet surveys	MN DNR	8 surveys on the forest in 2018. 65 routes Statewide	Pilot project in 2018. Plans to continue in future years with goal of tracking population trends over time.
American Woodcock	Annual listening surveys. 10 stops per route	USFWS	8 routes on the forest. Statewide survey routes established in 1970s.	Yearly population status report published by USFWS
MAPS (Monitoring Avian Productivity and Survivorship)	Constant effort mist-netting and banding of songbirds	Institute of Bird Populations	2 MAPS Station on SNF. Weiss Creek near Isabella established in 2007. New station near Ely in 2018. One non-FS station at Wolf Ridge ELC	Results from banding are combined with regional and national data. Provides population demographics.
Owls	Targeted rare owl survey routes. Annual listening surveys.	Hawk Ridge Bird Observatory	14 routes within SNF proclamation boundaries	Yearly report on species numbers. RFSS owls and more common species counted
Breeding Bird Survey	Annual listening surveys. 50 stops per route	USGS	5 routes within the Superior NF	Contributes to regional and national effort to track population trends
Butterflies	Annual count of species at specific sites	Volunteers Duluth Northern	Plouff Creek, McNair and Cook County	Yearly summary report for each site completed by volunteers and/or FS

Species/Group	Method	Partner	Number surveys	Comments
		Crescents Chapter		biologist. Some RFSS butterflies included
Bees	Species inventory	Great Lakes Restoration Initiative (GLRI)	50 acres inventoried on the forest in 2018	www.bumblebeewatch.org

Habitat Monitoring

Most habitat monitoring on the Forest is a coarse-scale look at changes in forest type and age across landscape ecosystems (MIH) and spatial patterns (see vegetation chapter). Fine-scale habitat features, such as the presence of large downed logs or snags, are important to many wildlife species but difficult and costly to measure.

The Plouff Creek bilberry (*Vaccinium caespitosum)* project on the Tofte District is one example where fine-scaled habitat variables are directly measured. Bilberry is the larval host plant for the northern blue butterfly, a regional forester sensitive species. Vegetation is measured yearly along monitoring transects to evaluate the response of bilberry to prescribed fire regimes. The LaCroix and Kawishiwi Ranger Districts both are developing a similar monitoring project to look at the effectiveness of prescribed burning in expanding oak blueberry habitats.

The Superior participates in an annual bear food survey each year that the MN DNR coordinates. This qualitative survey assesses the abundance of natural foods available to bears, calculating the abundance indices for summer foods (berries) and fall foods (oak, hazel, and dogwood). Changes in food abundance can assess changes in the bear population and to the likelihood of nuisance bear encounters.

- To what extent is Forest management moving toward short term (10-20 years) and long-term (100 years) objectives for habitat conditions for species associated with MIH?

Management indicator habitats (MIH) are groupings of forest cover types divided by age classes. By looking at trends in MIH, resource specialists can predict what the outcome might be to wildlife species associated with these habitats. For example, in looking at the distribution and availability of mature MIH 1 (upland forest types) as habitat for northern goshawk, there are MIH objectives defined for each landscape ecosystem (LE) in chapter 2 of the Forest Plan (USDA Forest Service 2004a). Table DEIS-6 of the Forest Plan displays the estimated Forest-wide acreage for each MIH for decades 2, 5 and 10 (USDA 2004, FEIS Vol. 11, Appendix D).

The vegetation chapter of this monitoring report discusses trends in MIH, while, effects to MIS species are discussed in section 2 of this chapter. Below is a brief overview of MIH trends across all landscape ecosystems (LEs) and some species that may be affected. See Forest Plan EIS (USDA Forest Service 2004a) p. 2.2.2.1-5 through 3.3.3.1-15, and Vol. II appendix D pp. D-26 through D-69 for a complete list of species and their associated management MIHs.

MIH 1 (upland forest), MIH 2 (upland deciduous forest) and MIH 5 (upland conifer forest). MIHs 1, 2 and 3 are general categories, and not summarized in this report. Additionally, this summary does not cover non-forested habitat and aquatic habitats. See the Forest Plan EIS referenced above for more information on MIH.

MIH3 Northern Hardwood Forest. Most of this forest type is within the sugar maple-dominated landscape primarily along the Northshore. In general, trends for young, mature, and old/multi-aged forest are following Forest Plan objectives. Some wildlife species associated with northern hardwood forest include ovenbird, black-throated blue warbler, yellow-bellied sapsucker, and least flycatcher.

MIH4 Aspen-birch and mixed aspen-conifer forest. This habitat type is abundant across the Forest. In general, the first decade of the Forest Plan did not meet objectives for young aspen-birch and mixed aspen-conifer forest, and the second decade has less young that project thus far. Mature aspen-birch and mixed aspen-conifer forest is increasing across some landscapes, which is opposite of most Forest Plan objectives. Old/multi-aged forest trend is increasing in some landscapes (mesic-birch aspen LE, jack pine/black spruce LE) where the objective is to decrease. This increase in mature and old growth forest could benefit some species such as pine marten, fisher, northern goshawk (RFSS, MIS), Swainson's thrush, and pileated woodpecker. The Forest has not met young forest objectives resulting in less habitat for species including ruffed grouse, white-tailed deer, and American woodcock.

MIH6 Upland Spruce-Fir Forest. In general, the Forest is on track to decrease the acreage of young upland spruce-fir Forest wide. Some species using young spruce-fir habitats include snowshoe hare, white-throated sparrow, and dark-eyed junco. Mature upland spruce-fir forest is increasing in some areas that is trending away from plan objectives. Old/multi-age forest is generally following Plan objectives but below desired conditions in the DRW LE and may be above objectives in the MRW LE by 2024. Species using mature and older spruce-fir forests include snowshoe hare, magnolia warbler, and bay-breasted warbler. MIH6 habitat is generally on track with Forest-wide objectives but project analysis should consider the spatial distribution of this type for possible effects on associated wildlife species.

MIH7 Red and White Pine Forest. Forest-wide trends in young, mature, and older red and white pine forest are following Plan objectives across most of the Superior. Wildlife species using young red and white pine forest include snowshoe hare and whip-poor-will. Pine warbler, red-breasted nuthatch, and bald eagle are also associated with older red and white pine.

MIH8 Jack Pine Forest. Objectives for young jack pine are not being met, which is of particular concern in the more central and northern parts of the Superior (jack pine black spruce LE). This results in less habitat for wildlife species that use young jack pine stands, including the northern blue butterfly and heather vole. The acreage of mature jack pine is near desired objectives but there is more in the old age class than desired. Spruce grouse and black-backed woodpecker are using these older jack pine stands and may benefit from this condition.

MIH9 Lowland Forests. The Superior was not on track for achieving decade 1 objectives for young lowland forest but is on track for decade 2. In addition, the Superior is meeting objectives to decrease mature forest and increase old growth/multi-age forest. Wildlife species associated with lowland forest include moose (RFSS), Connecticut warbler (RFSS), yellow-bellied flycatcher, great gray owl and boreal owl (RFSS), gray jay, and yellow-rumped warbler. The MIH9 habitat is generally on track with Forest-wide objectives for decade 2, but the Forest should consider spatial distribution of this type during project analysis for possible effects on associated wildlife species.

5.15.2 Management Indicator Species (Wildlife): Bald Eagle and Northern Goshawk

The Forest Plan designated four species as management indicator species (MIS): bald eagle, northern goshawk, gray wolf, and white pine. This section addresses bald eagle and northern goshawk. The threatened and endangered species sections reports on the gray wolf, while the vegetation chapter reports on white pine.

5.15.2.1. Management Indicator Species (Wildlife) Monitoring Questions

MIS monitoring addresses the following monitoring questions listed for wildlife: MIS from chapter 4 of the Forest Plan:

- What are the population trends of management indicator species (MIS)?
- To what extent is Forest management moving toward short term (10-20 years) and long-term (100 years) objectives for habitat conditions management indicator species?

Drivers and Indicators for Monitoring Questions

The 1982 Planning Rule (36 CFR 219.19 (a)(6)), under which the Forest Plan was developed, contained a rigorous requirement for the monitoring and identifying of population trends of management indicator species, and the relationships to habitat changes over time. Since 1982, our understanding of land management planning has advanced, particularly in the areas of conservation biology and ecology. Management indicator species is one concept no longer supported by the best available scientific information. The 1982 rule largely relied on the selected MIS and their associate habitat conditions to represent assessing vertebrate species viability for all other vertebrates in the Plan area. Even though the process of assessing and selecting MIS has evolved, the ability of a species or species group, on its own, to adequately represent all associated species that rely on similar habitat conditions is now largely unsupported in the scientific literature. Management indicator species monitoring has had legal debates and the Superior recognizes that monitoring the population trend of one species should not be used to form conclusions regarding the status and trends of other species. In addition, population trends for most species are extremely difficult to determine within the 15-year life of a plan. It may take decades to establish accurate trend data, and require additional data needs for broader areas then an individual national forest. For these reason and more, the Forest Service issued a new Planning Rule in 2012 that does not include MIS planning and monitoring. Although the Forest Service is not required to follow the outdated MIS monitoring requirements of the 1982 Planning Rule, the Forest Plan contains the following direction that drives the two questions above:

- Provide ecological conditions to sustain viable populations of native and desired non-native species and to achieve objectives for management indicator species (O-WL-1).
- Promote the conservation and recovery of the bald eagle. Population goal minimum: 85 breeding territories. (O-WL-16).
- Northern Goshawk: Provide habitat to provide for population goal minimum: 20:30 breeding pairs (O-WL-31).

The Plan developed the monitoring questions to determine the extent that Forest management is moving conditions toward short-term (10-20 years) and long-term (100 years) objectives for bald eagle and northern goshawk populations and habitat conditions. Current ecological conditions and habitats help in making informed decisions during project-level analyses and guide future management decision.

Indicators and measurement units for these monitoring questions generally focus on habitat conservation and minimizing human disturbance to MIS species. The Forest Plan explains the thresholds and measurements come from as standards, guidelines, and objectives. Appendix MIS-1 of this chapter contains a complete list of indicators, methods, and measurements.

Bald Eagle Results and Analysis

- In 2007, the U.S. Fish and Wildlife Service removed the bald eagle from its list of federally threatened species as populations were considered recovered.
- In 2007, the Forest added the species to its regional forester's sensitive species (RFSS) list following its delisting from the federal list.
- In 2013, Minnesota removed it from the State's list of threatened species.
- Finally, in 2017, the Forest removed the species from the RFSS list following a risk evaluation. Bald eagle monitoring continues on the Superior National Forest as a management indicator species.

Bald eagles and their nests remain protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. The U.S. Fish and Wildlife Service has prepared National Bald Eagle Management Guidelines to help landowners, land managers, and others to avoid disturbing bald eagles.

Bald Eagle Population Trends

The bald eagle population in Minnesota has made a remarkable recovery after nearly disappearing from the State prior to 1970. Minnesota currently has the highest bald eagle population in the contiguous 48 states and the population continues to grow (Naumen 2017). Statewide surveys showed an increase from slightly over 100 to 872 active known nest locations between 1973 and 2005 (https://mnbirdatlas.org/species/bald-eagle/ (Baker 2006). In 2017, the MN DNR reported 9,800 bald eagle pairs in the state (Naumen 2017). Migration counts at Hawk Ridge in Duluth continue to show a steadily increasing population migrating through in the fall (http://rpi-project.org/).

In 2009, the U.S. Fish and Wildlife Service published a comprehensive post-listing bald eagle monitoring plan for the contiguous 48 states recommending five-year monitoring intervals for 20 years post de-listing (USDI FWS 2009). In 2018, the USFWS initiated a range-wide bald eagle survey identified in the post-delisting monitoring plan. When completed, the results of this monitoring effort will be reviewed and considered in a future monitoring report. There has not been a statewide survey effort for bald eagles since 2005.

In the past, monitoring of the bald eagle population on the Superior National Forest demonstrated that the Forest was meeting the population goal of 85 breeding pairs (O-WL-16). The last extensive eagle survey on the Superior was in 2005, in cooperation with the State survey. During 2005, the Forest reported 90 active nests, which was an increase of 15.4 percent from the previous survey in 2000 (Baker 2006). Productivity surveys on the Forest in 2000 found 1.14 young produced per occupied breeding territory (USDA 2004).

Current bald eagle nest survey efforts on the Superior do not attempt to inventory every active nest but focus on nature and project-specific locations. Forest management activities aim to protect or maintain potential habitat near lakes and streams and to buffer nests from disturbance. During project planning and analysis, specialists consider potential impacts to eagle and if

warranted, conduct project-specific low-level aerial surveys to search for new nests or check known nests.

The Minnesota Breeding Bird Atlas (BBA) provides another look at the bald eagle population across the State and on the Superior. A breeding bird atlas is, "a comprehensive, systematic field survey of the occurrence and breeding status of breeding birds, conducted by citizen scientists during a limited time period." The first MN BBA was completed in 2017 and results of this five year project are available online (https://mnbirdatlas.org/species/bald-eagle/). Bald eagles were reported in 120 (15 percent) of the 790 survey blocks within the proclamation boundaries of the Forest. There are 44 confirmed nesting records and 9 "probable" breeding records from this effort. The remaining records fell into the categories of "observed" (30) and "possible" (37).

Bald Eagle Habitat Conditions

The Forest used acreage of young red and white pine forest as an indicator of future nesting habitat. Currently, fewer acres of red and white pine exist in this age class than projected for decade 2 (table 5.15-2). White pine interplanting and underplanting on the Forest adds to this young pine component but is more difficult to measure. Thus, white pine makes up a component of another stand type. Since 2004, the Forest has planted over five million white pine seedlings. (White pine MIS section).

Two habitat indicators for bald eagle measure include:

1. Acreage and percentage of red and white pine on the Forest.
2. Acreage and percent of old-growth red and white pine.

There are slightly fewer acres of red and white pine forest in 2017 than projected for decade 2 but not enough to change the percentage on the landscape from 13 percent. There are more acres of old-growth red and white pine forest in 2017 than projected for the second Decade (table 5.15-2). Overall, habitat conditions for bald eagle look promising now and into the future.

The 2004 biological assessment for the Forest Plan included disturbance indicators for bald eagle (USDA 2004). These are similar to those used for lynx and wolf and results are in the threatened and endangered section of this monitoring report. In general, disturbance indicators in 2017 and projected to 2024 are within the predictions of the Forest Plan. Eagles are believed to be more adaptable and tolerant of human presence than previously believed (Grier and Guin 2003).

Table 5.15-2. Bald eagle-acres and percent of forest in the following conditions for red and white pine forest

Year	Young (Acres)	Old Growth >100 years [1] Acres (Percent)	Total Forest Type [2] Acres (Percent)
2004	15,000	20,600 (50)	107,400 (11)
2014	10,409	28,149 (52)	128,785 (13)
2017	3,476	31,473 (55)	126,632 (13)
2024 Projected	4,286	34,804 (57)	130,041 (13)
Decade 1 FP FEIS Projected Condition (2014)	9,200	25,700 (52)	117,500 (12)
Decade 2 FP FEIS Projected Condition (2024)	8,400	28,000 (49)	127,600 (13)

1 Percent of total red and white pine forest type (FT 2, 3 and 30)

2 Percent of all upland forest = 970,914 acres

Forest Plan FEIS Volume 1, p. 3.3.4.3.

USDA 2004 Biological Assessment for Forest Plan Revision

Northern Goshawk Results and Analysis

The northern goshawk is a regional forester sensitive species as well as a Forest management indicator species. In 2013, the State officially listed it as a Special Concern Species in Minnesota and a Species in Greatest Conservation Need.

Northern Goshawk Population Trends

The northern goshawk is widely distributed across the boreal forest region of Canada, Alaska, the northern Great Lakes states, New England, and the western United States but is uncommon throughout its range. Partners in Flight recently estimated the North American population of this global species at 210,000 breeding adults. Unfortunately, there is low reliability in this number but species-specific monitoring to obtain population estimates has generally been too costly to implement. A regional survey across the entire western Great Lakes in 2008 found goshawks were occupying 27 percent of potential habitat (Bruggemen 2011).

The population trend for northern goshawk across its range or on the Superior National Forest is unknown. Goshawk populations are known to be cyclical, which is believed to be a function of changes in prey populations. Fall migration counts at Hawk Ridge in Duluth show this pattern with peaks in the past above 4,000 and lows below 100 birds. Migration counts conducted at Hawk Ridge in Duluth from 1970 to 2013 showed a significant downward decline in the number of Northern Goshawks (https://mnbirdatlas.org/species/northern-goshawk/). Habitat loss, changes in prey abundance, climate change, or a combination of these factors attribute to the declines.

The MN DNR has been monitoring goshawk territories to check occupancy and track productivity. From 1991-2012, 130 active territories were identified within the State. Statewide, an average of 29 reported nest attempts per year. Nesting success in Minnesota appears to be lower than in other regions of North America but still within the reported range of values. (https://mnbirdatlas.org/species/northern-goshawk; Boal et al. 2006)

The Superior National Forest collaborates with the MN DNR to check on goshawk territories across the Forest. The number of goshawk territories monitored each year has steadily increased since 2004 and has ranged from 20-35 in any given year (figure 5.15-2). There is variability in the number of territories found occupied each year, possible reflecting the cyclical nature of goshawk populations. Some variability attributes to the search effort that is a function of weather and road conditions, personnel, and funding.

The Forest uses goshawk feather collection and DNA analysis for information on the Forest's population. The data generated from these efforts can identify individuals, evaluate re-captures and spatially evaluate nesting sites used by individuals year after year (Pilgrim 2013, Pilgrim 2014).

Forest Plan objective O-WL-31 is to provide enough habitat on the Superior for a minimum population goal of 20-30 breeding pairs. The number of confirmed breeding pairs documented each year on the Superior has ranged from 8-19 (figure 5.15-2). However, it is very likely that there is additional nesting on the forest that go undocumented given the secretive nature of this species. There has not been a Forest-wide survey to find new goshawk territories since 2008 and there are no surveys in the BWCAW where suitable habitat occurs. Habitat monitoring indicates that there is enough suitable habitat now and projected into 2024 to meet the Forest Plan population objective (see Habitat Conditions Section below).

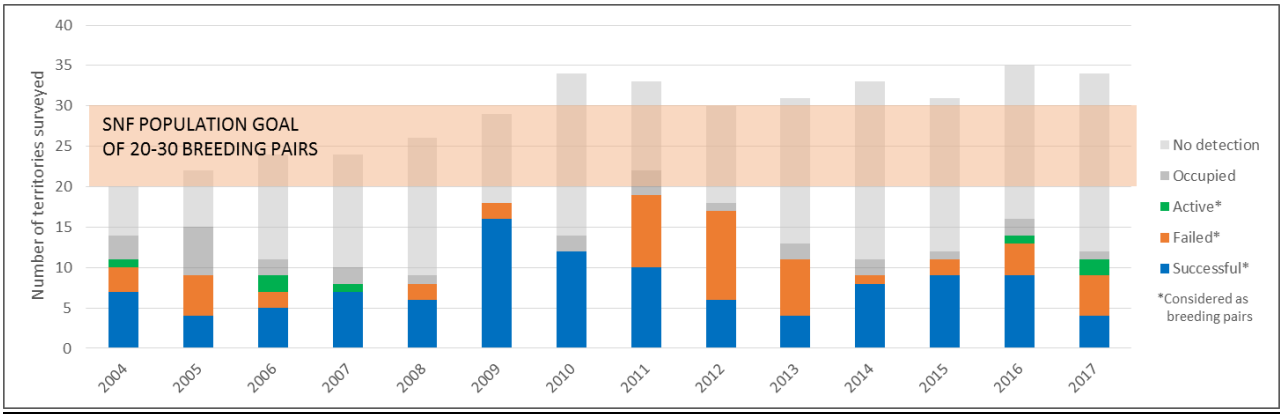


Figure 5.15-2. Occupancy status and nesting success of northern goshawk territories surveyed on the forest from 2004-2017

Northern Goshawk Habitat Conditions

Resource specialists used three indicators to monitor goshawk habitat conditions on the Forest:

3. Percent of mature uplands on the landscape.
1. Number and acre of mature forest patches.
2. Stand complexity (USDA FEIS Vol. 1 2004).

Table 5.15-3-2 summarizes results for the first indicator. The Forest tiers to the vegetation section of this monitoring report to discuss the second indicator. Stand complexity is an indicator that was not included in this report but we recommend it for future reports.

Table 5.15-3 displays mature upland forest results for the second decade of the Forest Plan. In 2017, 59 percent of upland forest was in the mature or older growth stage. A slight decrease to 56 percent is projected for 2024 but this is still 10 percent above decade 2 projections in 2024 (figure 5.15-3). The Forest Plan BE and general recommendations in the literature suggest maintaining between 40-80 percent of upland forest in the mature or older growth stage. Results of this indicator show that mature forest habitat conditions remain sufficient for maintaining goshawks on the forest.

Table 5.15-3. Percent of mature and older upland forest (MIH 1) by year

Decade/Year	Percent (%)
Superior Existing and Current Habitat Prediction for Decade 2[1]: 2014	57
2017	59
2024	56
Decadal Habitat Predictions from the Forest Plan and 2004 Biological Assessment[2]: Decade 1 FP FEIS Projected Condition (2014)	48
Decade 1 FP FEIS Projected Condition (2014) with BWCAW	47
Decade 2 FP FEIS Projected Condition (2024)	46
Decade 2 FP FEIS Projected Condition (2024) with BWCAW	46

1. Calculated for uplands outside of BWCAW
2. Forest Plan FEIS Volume 1, p. 3.3.6-4 Alt. E. Optimal range 40-80%

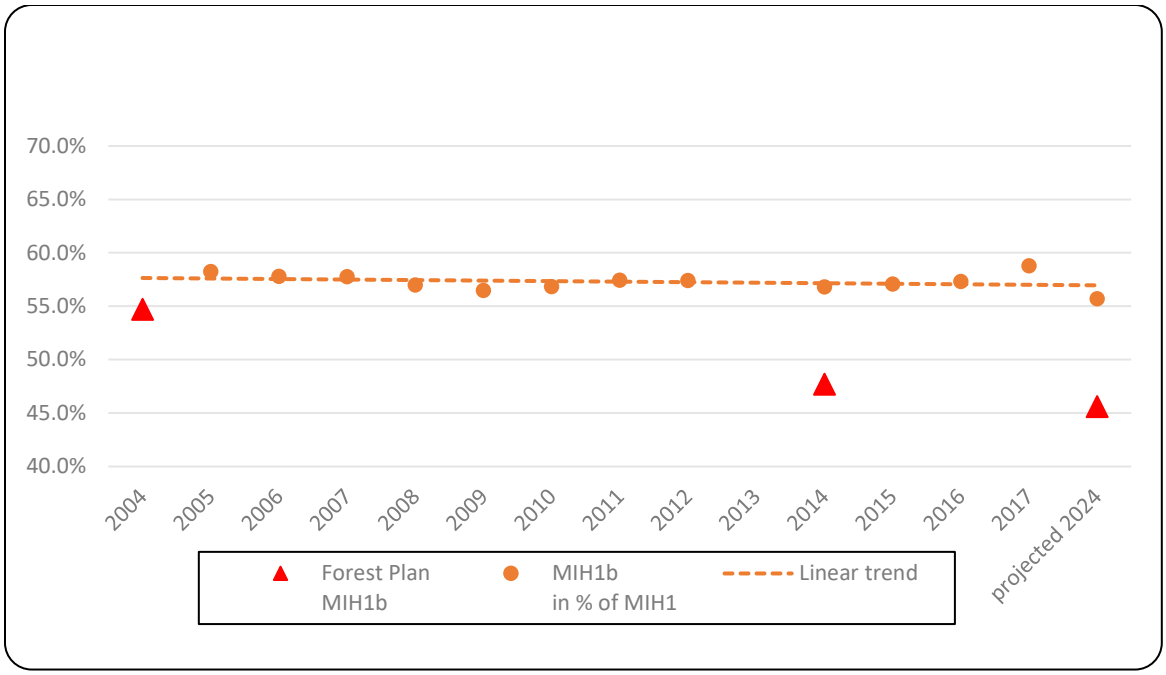


Figure 5.15-3. Percentage of MIH1 upland forest acres in mature+ age class outside of the BWCAW and decade two-habitat projections

Another habitat indicator for northern goshawk is the number and acres of large (100 acre+) upland mature patches on the Superior. Figure 5.15-4 shows the number of 100+ acre mature upland patches is decreasing and in line with projections from the Forest Plan. However, acres in large upland mature patches is increasing (figure 5.15-5). This is similar to the number and acres of mature upland patches greater than 300 acres. One likely explanation for this is that management activities have changed the stand age in 100 and 300-acre patches and reduced their number while mature patches larger than this have increased in acreage. In summary, mature forest available in large patches is more abundant on the landscape than projected by the Forest Plan. A more detailed analysis of forest patches is in the vegetation chapter of this monitoring report.

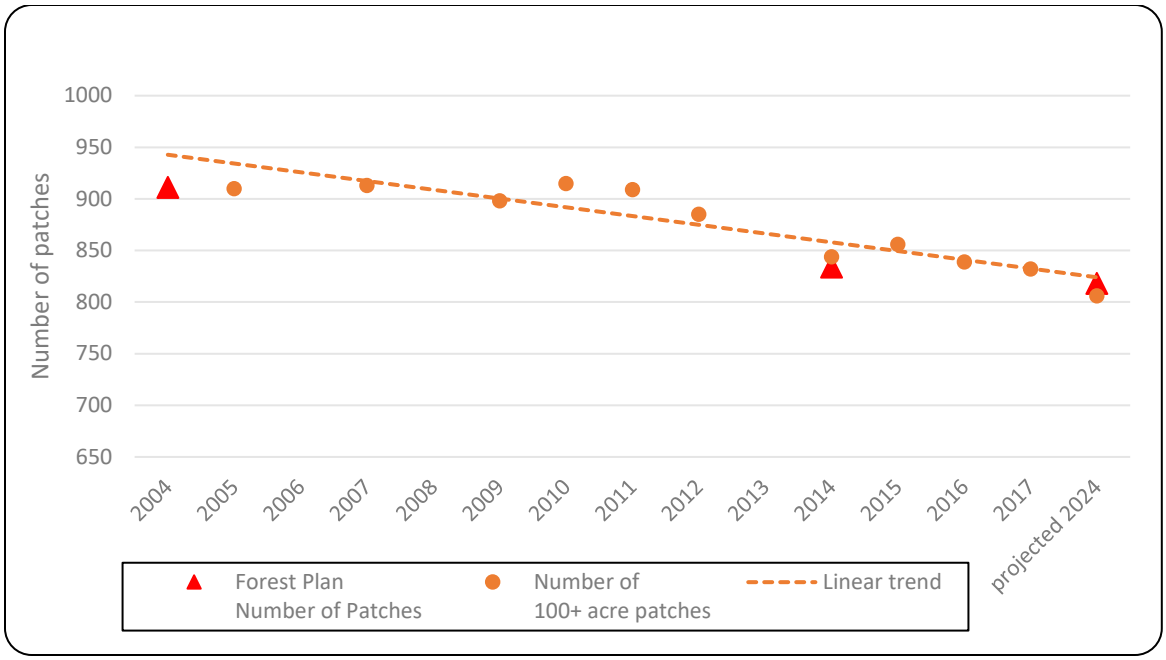


Figure 5.15-4. Northern goshawk nesting and foraging number of 100+-acre upland patch

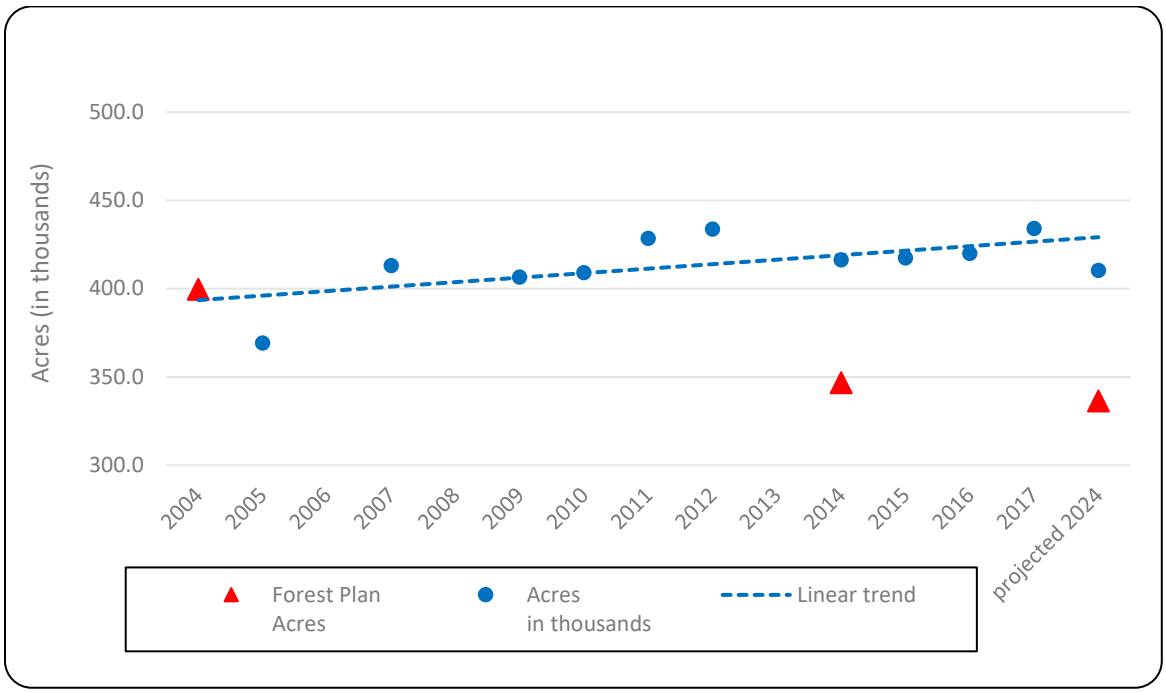


Figure 5.15-5. Northern goshawk nesting and foraging acres of 100+ acre upland patches

The Forest Plan goshawk indicator for stand complexity was a measure of harvest management practices. Even-aged regeneration is the primary method of treatment in modified alternative E (selected alternative), making up 90 percent of all timber harvest treatments (USDA FEIS Vol. 1, 3.2-36; 3.3.6-9). Forest stands harvested using these methods are unlikely to remain suitable for northern goshawk until they reach maturity again in fifty or more years.

5.15.3 Regional Forester's Sensitive Species (Terrestrial)

The Superior National Forest contributes to the conservation of regional forester sensitive species (RFSS) with habitat improvement and project mitigations and protections at known sites. This section describes the monitoring of 15 terrestrial animals listed as RFSS for the Forest. This section does not include sensitive aquatic or plant species. The RFSS are only one component of wildlife species that the Forest monitors and manages. Other related wildlife subsections include management indicator species (bald eagle and northern goshawk) and threatened and endangered species (Canada lynx, gray wolf, and northern long-eared bat). The Wildlife and their Habitats section (5.15.1) and the vegetation chapter (5.13) also contains monitoring data and results that describe changes to vegetation important for wildlife habitat. The Forest Plan and FEIS utilized the 2000 RFSS list. Since then, updates the list in 2006, 2012, and 2017 have resulted in changes to terrestrial animal species based on the outcome of risk evaluations using new information. This section reflects the terrestrial animal species on the 2017 list (UDSA FS 2018).

5.15.3.1 Regional Forester's Sensitive Species (Terrestrial) Monitoring Questions:

- To what extent is Forest management contributing to the conservation of regional forester's sensitive species (RFSS) moving toward short term (10-20 years) and long-term (100 years) objectives for habitat conditions?

The 1982 Planning Rule (36 CFR 219.19 (a) (6)), developed the Forest Plan and provides the driver for the monitoring question related to RFSS. Although the Forest Service is no longer bound by the monitoring requirements of the 1982 Planning Rule, the Forest Plan contains the following direction that drives the monitoring question above related the RFSS. More Forest Plan direction is contained in objectives, standards, and guidelines related to the management and protection of RFSS.

- Aquatic and terrestrial wildlife habitats and species populations, while constantly changing due to both management activities and naturally occurring events, are present in amounts, quality, distribution, and patterns so that NFS lands: Contribute to the conservation of sensitive species and the habitats upon which these species depend. (D-WL-3b)
- Maintain, protect, or improve habitat for all sensitive species. (O-WL-18)
- Maintenance, protection, and/or enhancement of individual sensitive species' habitat, especially breeding habitat and known sites. (O-WL-19 through O-WL-17)
- Avoid or minimize negative impacts to known occurrences of sensitive species. (G-WL-11)
- Minimize negative impacts to known sensitive species from management activities that may disturb pairs in their breeding habitat during critical breeding season (varies by species). (G-WL-12)

Species-specific direction and drivers are located in the monitoring and evaluation project file.

The Forest Plan provides direction to maintain viability of all native and desired non-native species. (Wildlife and Their Habitats section of this chapter). For RFSS there is an added responsibility to ensure that management activities do not result in a significant trend towards federal listing (FSM 2670.22). Forest Service policy (FSM 2671.1-2672.43) requires evaluation of impacts to RFSS from management activities. Meeting Forest Plan direction for RFSS requires diverse management and monitoring approaches that depend on species' habitat

requirements and distribution, individual site conditions, and expected management impacts. These include two basic and complementary strategies:

1. Landscape level or coarse filter management and monitoring strategies that address species' needs through integrated landscape scales such as LE or LTA scales for vegetation and MIH objectives. May allow negative modifications o some sensitive species' habitat if overall objectives for habitat amount, quality, and distributions are generally met.
2. **.**Site-level or fine-filter management and monitoring strategies that address species' needs by managing specifically for high-quality potential habitat or known locations of sensitive species. Includes protections of known individual sensitive species locations or high quality potential habitat. If negative impacts to sensitive species are unavoidable, management activities must avoid loss of species viability Forest-wide or create significant trends toward federal listing (S-WL-5).

The monitoring question is appropriate for RFSS because most of our sensitive species are rare, have limited distribution, have declining or unknown population trends, and occur in habitats affected by our management. Through monitoring, the Forest looks at management actions that may affect species and adapts those actions to maintain viability of populations. Specialists also determine if the Forest is meeting or moving toward the desired conditions of diverse, healthy, productive and resilient wildlife habitats for sensitive species. Finally, it also gives a chance to reevaluate species population trends and risks while considering the latest scientific information.

Methods and Indicators

Forest staff monitor RFSS in two general way: species monitoring or direct monitoring of individuals and/or populations, and habitat monitoring. The following indicators and methods for these two general categories are:

Species Monitoring: In general, the Forest Service, partners, and other conservation organizations use four primary methods for monitoring terrestrial animal RFSS species and populations. Species monitoring helps answer the part of the monitoring question related to species conservation. Methods include:

1. Occurrences: To obtain the occurrences number, specialists compare the number of known or documented sites of RFSS from 1960 to 2004 to the number of currently known occurrences. The Minnesota Department of Natural Resources biotics database and the Forest Service's natural resource management-wildlife database track the species accounts lists of known RFSS occurrences.
2. Presence/no detection: Detection surveys contribute to the number of known sites for any species and its habitat use. For most RFSS population, monitoring is prohibitively expensive because the species' rarity makes it impractical to track enough individuals. Therefore, the Forest relies on monitoring methods that detect presence and non-presence, as well as distribution. For most large landscape-scale[8] vegetation management projects, specialists conduct surveys to detect whether species are present during the breeding season or other appropriate time, even though the absence of a detection is not a certainty that the species does not occur here. Because of timing of the survey, rarity of the species, weather or some

[8] Approximately 10,000s of acres

other factors, missed detection of individuals in suitable habitat may occur. The purpose of surveying is to attempt to improve the understanding of habitat associations by surveying across projects in potential habitat and over time (years). In addition, the purpose of these types of surveys is to discover new sites requiring protection from potentially harmful management activities. Moreover, specialists also return to known breeding sites (occurrences) to monitor whether the species is continuing to use the areas.

3. Population trends – This involves multiple years of surveying a large enough number of individuals ("sample size") to allow an accurate estimate of population trend[9]. Because it is not possible to count every individual species, the Forest relies on monitoring data to provide an "index" or indicator of population. The location of this monitoring is usually at the Forest-wide or larger geographic area and not tied to project areas only. For some species, population trends are at the extent of the species range.
4. Breeding territory and productivity – For a few species whose breeding territories or nest or denning sites have been located, Forest staff also conduct site occupancy and breeding success surveys. These survey results also contribute to understanding population dynamics, management impacts, and add to information used to develop indices of populations.

See the monitoring and evaluation report project file appendix RFSS-1 for specific species-by-species details of monitoring for each category.

The number of occurrences, presence/no detection, and breeding territory and productivity are good indicators because they allow Forest staff to determine whether our standard operating procedures, such as avoidance and buffering of known locations, are providing the desired protection for sensitive species near managed areas. These measures are effective and appropriate because they provide information on species' distribution and track breeding activity at known occurrences of sensitive species. The Forest tracks these measures yearly and compare them to the 2004 data, the first year of Forest Plan implementation.

Population trends measure the reflected changes on a scale larger than, but inclusive of, the Superior National Forest, and warn us of viability concerns. Viable populations are those with the estimated numbers and distributions of reproductive individuals to ensure their continued existence is well distributed within their range in the planning area (Forest Plan D-WL-3b).

Habitat Monitoring: The Forest monitors landscape-level (coarse filter) habitat conditions in several different ways to address consistency with Forest Plan management direction to maintain, protect, or improve habitat for RFSS and the portion of the monitoring question for habitat conditions. See appendix RFSS-1 for specific species-by-species details of habitat monitoring conducted. Units of measure for habitat monitoring of most RFSS are trends in associated management indicator habitats (MIH) compared with 2004 conditions, decade 1 and 2 objectives, Forest Plan FEIS predicted levels, and range of natural variability (RNV) values (where appropriate) as an assumption of species viability. These units of measure are effective and appropriate because they track changes in habitat

[9] Direction and magnitude of population change over time and/or population trajectory (the size of the population over time)

necessary to support viable RFSS populations. See the vegetation chapter section 1 for more information on MIH.

Some species such as monarch butterfly, do not lend themselves to the use of MIH. For those species, habitat conditions are assessed by methods such as site visits to check habitat or aerial photo interpretation to determine suitability or the potential for impacts from management.

Forest specialists also monitor site-level (fine filter) habitat for some species. For example, specialists visit known nests or breeding territories of northern goshawk, boreal owl, great gray owl, and wood turtle to check on conditions and management impacts.

Results, analysis, and evaluation

RFSS Species Monitoring Summary

RFSS species monitoring helps to answer, *"To what extent is Forest management contributing to the conservation of sensitive species."*

Multiple-agency/conservation organization monitoring accounts for much of the data the Forest uses to track on known location and population trends of RFSS. Superior National Forest biologists participate in and review the findings of many cooperative monitoring programs, as listed below. The Forest uses the data from these programs during project analysis and monitoring report analysis. While not all data are annually updated, specialists use the most up-to-date available information.

Key sources for species monitoring (occurrence, presence/no detection, population trends, and breeding territory/productivity) vary by species. Specialists collaborate with the following groups for project-specific and above project SNF RFSS surveys:

- The Minnesota Department of Natural Resources (MN DNR) wildlife and non-game surveys, along with natural heritage program studies.
- Tribal partners.
- NatureServe.
- Minnesota Breeding Bird Atlas.
- Western Great Lakes Owl Monitoring for avian productivity and survivorship stations (MAPS).
- The Natural Resources Research Institute (NRRI) forest songbird-monitoring program.
- USFWS breeding bird surveys.
- North American Butterfly Association and other annual counts.
- Local knowledge.

See appendix RFSS-1 for detailed species monitoring results for each terrestrial RFSS between 2004 (Forest Plan revision) and 2017 where data are available. Below is a summary of those results.

Species occurrence data is available for 14 of 15 terrestrial RFSS and presence or no detection data are available for 10 of 15 terrestrial RFSS (Table 5.15-4). These results can be us help the Forest determine which species need changes or increases in species monitoring efforts.

Species occurrence and presence/no detection data show there has been an increasing number of known locations for the following eleven species: moose, little brown bat, eastern heather vole,

northern goshawk, great gray owl, olive-sided flycatcher, Connecticut warbler, American three-toed woodpecker, wood turtle, monarch butterfly, and northern blue butterfly since 2004. The increase for these species likely are indicative of increases in effort to survey and monitor rather than increases in population. For example, in 2005, the MN DNR and partners developed and implemented an annual aerial moose survey that has resulted in annual detections of moose sites. Additionally, between 2013 and 2017 the SNF participated in a bat netting survey with partners that resulted in an increase in detection of little brown bats, and so forth. Since 2004, there has been no change in the number of sites for the following four species: tri-colored bat, boreal owl, Taiga alpine butterfly, and Frejia's grizzled skipper. The Superior National Forest is located at the southern extent of the range of boreal owl, taiga alpine butterfly, and Frejia's grizzled skipper; and the northwestern extent of tri-colored bat range contributing to the rarity of these four species. Since then, varying levels of survey and monitoring efforts of these species lead us to questions such as:

- How rare are they?
- How intensively have researchers looked for them?
- Are current monitoring methods adequate to detect them?
- Are database up-to date with all known locations?

Future work and assessment would help to determine if these species warrant an increase in surveying and monitoring.

Table 5.15-4. Species occurrence and present or no-detection results in 2017, compared to 2004

Increase Number of Locations	No Change in Number of Locations
Moose	Tri-colored bat
Little brown bat	Boreal owl
Eastern heather vole	Taiga alpine butterfly
Northern goshawk	Frejia's grizzled skipper
Great gray owl	
American three-toed woodpecker	
Wood turtle	
Monarch butterfly	
Northern blue butterfly	

Known population trends for 11 of 15 terrestrial RFSS is at the range-wide scale that extends outside of the US for some species (table 5.15-5). These data show there are no terrestrial RFSS with increasing trends. Four species have relatively stable trends (less than or equal to a10 percent change): northern goshawk, great gray owl, taiga alpine and Freija's grizzled skipper; and seven species with decreasing trends (greater than 10 percent change): little brown bat, tri-colored bat, olive-sided flycatcher, Connecticut warbler, American three-toed woodpecker, wood turtle and monarch. No range-wide population trend data is available for four species: moose, eastern heather vole, boreal owl, and northern blue butterfly.

Table 5.15-5. Range-wide (NatureServe) results for regional forester sensitive species population trends

Increasing	Relatively Stable (<=10% change)	Decreasing (> 10% change)	No Trend Data
none	Northern Goshawk Great Gray Owl Taiga Alpine Freiga's Grizzled Skipper	Little Brown Bat Tri-colored bat Olive-sided Flycatcher Connecticut Warbler Am. Three-toed woodpecker Wood Turtle Monarch	Moose Eastern Heather Vole Boreal Owl Northern Blue Butterfly

Importantly, although population trends for some species appear to be relatively stable (less than or equal to 0 percent change), the bulk of the range of northern goshawk, great gray owl, taiga alpine, and Freija's grizzled skipper occurs in Canada. In the lower 48 states, taiga alpine is only know to occur in MN; Freiga's grizzled skipper occurs from MN, ID, and WY; great gray owl from MN,WA, OR, ID, CA, MT and WY; and northern goshawk from the western states, great lake states, northeastern states, SD, and WV. Where these species occur in the lower 48 states, there is generally reported a higher concern for their status and viability.

Population trends are known for five of 15 terrestrial RFSS (table 5.15-6) at the local level[10].). These data show there are no terrestrial RFSS with increasing trends; two species with stable trends: moose and wood turtle; and three species with decreasing trends: little brown bat, olive-sided flycatcher, and Connecticut warbler. No local-level population trend data are available for nine species: eastern heather vole, northern goshawk, boreal owl, great gray owl, American three-toed woodpecker, monarch, taiga alpine, northern blue butterfly and Freija's grizzled skipper.

[10] The definition of local level varies by species; however, it generally includes the Superior National Forest. See individual species records in the monitoring and evaluation report project file for specifics.

Table 5.15-6. Trend results for local-scale regional forester sensitive species populations

Increasing	Stable	Decreasing	No Trend data
none	Moose Wood Turtle	Little Brown Bat Olive-sided Flycatcher Connecticut Warbler	Tri-colored bat Eastern Heather Vole Northern Goshawk Boreal Owl Great Gray Owl Am. Three-toed Woodpecker Monarch Taiga Alpine Northern Blue Butterfly Freija's Grizzled Skipper

Interestingly, for most RFSS, the Forest was not able to determine local population trends. Two factors of this is rarity of the species and difficulty in surveying for them. Therefore, these factors contribute to the inability to both scientifically and rigorously determine local population trends. Some species such as eastern heather vole and boreal owl have shown declining survey results in portions of their Forest range. For other species such as Freija's grizzled skipper, detection has only been possible from one Forest location, so determining a population trends is not possible.

Breeding territory and productivity data are available for three of the 15 terrestrial RFSS: moose, wood turtle and northern goshawk. For moose, these data indicate that although pregnancy rates are robust, calf survival to January remains low, and spring recruitment of calves remains low. For northern goshawk, these data indicate that on average 40 percent or less of all known territories have breeding pairs in a given year, and that the breeding pairs success rate is quite variable (see appendix RFSS-1 and MIS section of this chapter for more information on N. goshawk). For wood turtle, data are too limited for sites within the national forest to make conclusions.

The overall results of RFSS species monitoring highlights the difficulty in surveying and monitoring for rare species. However, the data does indicate that these species are still appropriate for RFSS status and the special attention of that status. These data reinforce the importance of continuing to learn more about terrestrial RFSS and to track population changes relative to climate change and other factors that influence their ability to persist and thrive on the Forest. Continued monitoring of terrestrial RFSS, particularly those that are at the edge of their range, can help determine if range shrinking starts to occur. Species monitoring results also indicate that current Forest management is contributing to the conservation of RFSS species. Site-specific project level biological evaluations and project design also support these results. Since 2004, the SNF has not designed or implemented a project were a professional wildlife biological made a determination of a viability concern for an RFSS. Where needed and

appropriate, the SNF applies project design criteria that have mitigated effects and protected known RFSS species locations.

RFSS Habitat Monitoring Summary

RFSS habitat monitoring helps to answer *"To what extent is Forest management contributing to the conservation of regional forester's sensitive species (RFSS) moving toward short term (10-20 years) and long-term (100 years) objectives for habitat conditions?"*

Table 5.15-7. Selected management indicator habitat projections for decade 2 range of natural variability (RNV) comparison versus decade 2 levels predicted in the Forest Plan EIS

Within RNV but below Forest Plan decade 2 projected levels	below RNV but above Forest Plan decade 2 projected levels	Above RNV and above Forest Plan decade 2 projected levels
Young upland forest	Mature upland forest	Mature deciduous forest
Young conifer forest*	Mature conifer forest	Mature aspen/birch forest
Young jack pine forest*	Mature spruce-fir forest	Mature jack pine
		Mature lowland conifer

*2017 data shows that these indicators habitats are currently below RNV levels but are projected to be within RNV levels by 2024 with currently planned vegetation management.

Landscape Level (Coarse Filter) Habitat Monitoring

- Moose are generally associated with young upland forest for foraging habitat; sapling size or greater upland conifer-dominated forest and mature lowland conifer forest for thermal cover.
- Little brown bat and tri-colored bat generally use upland forest sapling size and larger for roosting habitat.
- Eastern heather vole is generally associated with mature and older jack pine forest.
- Northern goshawk is generally associated with mature and older upland forest
- Boreal and great gray owls are generally associated with mature and older aspen-birch and conifer dominated forest for nesting Boreal owl is more closely associated and mature lowland forest for foraging, whereas great gray owls associate more closely with young upland and lowland conifer dominated forest.
- Olive-sided flycatcher is generally associated with mature and older conifer dominated forest and mature and older lowland conifer forest.
- Connecticut warbler is generally associated with mature and older jack pine and lowland conifer forest
- American three-toed woodpecker is generally associated with mature and older forest dominated by spruce-fir, jack pine and lowland conifer.
- Wood turtle is generally associated with riverine habitat with mature deciduous forest along its shores.
- Taiga alpine is generally associated with mature lowland conifer forest.
- Northern blue is generally associated with young jack pine forest.
- Monarch butterfly and Freija's grizzled skipper do not have clear MIH habitat associations.

Habitat monitoring results show that forest management since 2004 has contributed to an imbalance of habitats compared to Forest Plan EIS predicted levels and the range of natural variation. Specifically, results show that there is more old forest habitats and less young forest habitats on the landscape today than the Plan analysis predicted there would be in 2014. Results also show that the current amount of young and old forest are generally outside the natural range of variation for these habitat types. This change towards older forest has generally benefited those RFSS that are associated with older forest habitats. The RFSS that use young forest, such as moose and northern blue butterfly, would benefit from an increase in forest management to create younger forest, particularly young jack pine. However, it should be noted that since 2004 when implementation of the current Forest Plan began, the biological evaluations for every project-level vegetation management projects have all maintained sufficient amounts of habitat for and viability of all RFSS, regardless of this imbalance. A primary explanation for this is that most of our Forest's RFSS use older forest habitats.

5.15.4 Federally Threatened and Endangered Species

This subsection outlines management and implementation monitoring completed for federally threatened and endangered species as required by the Endangered Species Act and the Forest Plan. Throughout the past 13 years of Forest Plan implementation (2004-2017), the Superior National Forest has contributed towards the conservation and recovery of federally listed species through habitat and access management practices; and through collaboration with other Federal and State agencies, researchers, tribal bands, and non-governmental partners. Currently, there are three species designated as federally threatened: Canada lynx, gray wolf, and northern long-eared bat. A threatened status means, "Likely to become endangered within the foreseeable future throughout all or a significant portion of its range" (ESA).

Between 2004 and 2007, the Superior National Forest (SNF) conservation and recovery efforts focused on three federally listed species: bald eagle, gray wolf, and Canada lynx. In 2007, the U.S. Fish and Wildlife Service removed the bald eagle was removed from the list of endangered and threatened wildlife as populations were considered recovered. The Forest continues to monitor the bald eagle t as a management indicator species (MIS). In addition, during 2015, the Forest added the northern long-eared bat to its list of federally threatened species.

5.15.4.1 Federally Threatened and Endangered Species Monitoring Questions

- To what extent is Forest management contributing to the conservation of threatened and endangered species (TE) and moving toward short term (10-20 years) and long-term (100 years) objectives for habitat conditions and population trends?
- To what extent are road and trail closures effective in prohibiting unauthorized motor vehicle use?
- To what extent is the Forest maintaining no net increase in groomed or designated over-the-snow trail routes unless the designation effectively consolidates use and improves lynx habitat through a net reduction of compacted snow areas?
- Wolf density and population levels

Drivers and Indicators for Monitoring Questions

The Endangered Species Act, 2012 Planning Rule (36 CFR 219.12(5)(iv)), and the Forest Plan provide drivers for monitoring questions related to federally listed threatened and endangered species. Indicators for these monitoring questions generally focus on conserving habitat and

minimizing human disturbance to TE species. The thresholds and measurements come from the Forest Plan as standards, guidelines, and objectives. The programmatic biological assessment discusses other indicators as conservation measures in recovery plans or in published federal rules. Appendix TE-1 of this chapter contains a complete list of drivers and question indicators.

Results and Analysis

- *To what extent is Forest management contributing to the conservation of threatened and endangered species (TE) and moving toward short term (10-20 years) and long-term (100 years) objectives for habitat conditions and population trends?*

Canada Lynx

The U.S. Fish and Wildlife Service (FWS) listed the Canada lynx as federally threatened in 2000. In their analysis of threats to the species, the FWS concluded that the single factor threatening the contiguous United States distinct population segment (DPS) of lynx was the inadequacy of existing regulatory mechanisms, specifically the lack of guidance for conservation of lynx in National Forest Land and Resource Management Plans and BLM Land Use Plans. In 2004, the Superior National Forest published the Forest Plan that includes design features and operational standards and guidelines to ensure that sufficient foraging, denning, and connectivity habitat remains on the Forest and to reduce the exposure of lynx to human disturbance factors. An updated Canada Lynx Conservation Assessment and Strategy in 2013 provides additional lynx management direction (Interagency Lynx Biology Team 2013). Results from two decades of lynx monitoring show a successful breeding population on the Forest with annual fluctuations in numbers.

In January of 2018, the U.S. Fish and Wildlife Service announced the completion of a scientific review of Canada lynx in the contiguous United States. The review concludes that Canada lynx may no longer warrant protection under the Endangered Species Act (ESA) and for possible delisting consideration due to its recovery. Since listing Canada lynx in 2004, there have been formal amendments and revisions to plans and implementation of conservation agreements adopted by federal managers and the Forest Service (Service); including conservation measures in the 2004 revision of the Superior Forest Plan. The recommendation to propose delisting the Canada lynx resulted from an extensive review of best available scientific information and almost 20 years of working in partnership with State, federal, tribal, industry, and other land managers on the conservation of this species. Because of this status review, the Service will begin development of a proposed rule to delist the Canada lynx. To delist a species, the Service must follow a process similar to what they use in considering whether to list species. The next step is for the Service to publish a proposed rule in the *Federal Register* (planned for fall 2019) initiating a public comment process, reviewing and analyzing those comments, conducting a peer review, and then announcing a final decision.

Conservation Efforts

Maintaining and Improving Habitat

On February 25, 2009, the USFWS designated revised critical habitat for the Canada lynx distinct population segment (DPS) in northeastern Minnesota. Both the 2004- revised Forest Plan and USFWS biological opinion (BO) provided direction in anticipation of critical habitat designation. The Forest Service wrote the Forest Plan objectives, standards, and guidelines with the goal of maintaining and improving critical habitat, and promoting conservation and recovery

of lynx. The 2011 biological assessment provides a crosswalk between the Forest Plan and project indicators and the primary constituent elements of lynx critical habitat (USDA 2011).

Lynx conservation is an important consideration when designing vegetation treatments on the Superior's districts. Specialists consider lynx habitat needs early in the planning process and carry them on through project design and analysis. For landscape-scale projects, this involves looking at the spatial distribution of forest types and age classes; as well as identifying important areas for lynx based on our population monitoring. In each project area, retention of some mature forest stands provides areas with structural diversity and cover; while harvesting others areas creates young vegetative growth for snowshoe hare and foraging areas for lynx. Specialists prescribe the underplanting and interplanting of conifers in mature forest stands to increase species and structural diversity. The TomaInga EA is one example of a recent large-scale vegetation project that used all of these methods with the objective of maintaining or improving habitat for lynx.

Lynx conservation planning also takes place at the Forest-wide scale. Between 2010 and 2012, the Forest spent over $250,000 to plant conifer and increase habitat diversity for lynx with funding from a Great Lakes Restoration grant. Other projects have improved lynx habitat security by closing roads and limiting access. The Forest monitors changes in roads and trails as discussed in more detail below.

Following the Biological Opinion

The Terms, Conditions, Reasonable, and Prudent Measures of the biological opinion (BO) require the Forest Service to work in partnership with other agencies to monitor and report lynx mortality (USDI 2011). The Fish and Wildlife Service "expects no more than one lynx would be taken annually (by vehicle) on the Superior National Forest and no more than 10 would be taken over the 10-year life of the Forest Plan due to vehicle collision on all roads on all ownerships within the Superior National Forest proclamation boundaries." (USDI 2011). "Take" includes to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Table 5.15-8 summarizes lynx take in decades 1 and 2 for the Superior NF. During the first decade, three lynx takings occurred from a vehicle collision (the subset of take that the FWS held the SNF accountable to by FWS). Take has not exceeded the annual limit of one in the second decade. Since 2014, motorized vehicles have killed two lynx, including one hit by a snowmobile.

Table 5.15-8. Summary of lynx take by decade and by type within the SNFs proclamation boundaries from 2004-2018*

Lynx Take Decade one of Forest Plan (2004-2013) Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**Total**
Vehicle[1]	1(1)	2(2)	0	0	0	0	0	0	0	0	3(3)
Other[2]	3(3)	4(3)	3(3)	0	1(1)	2(1)	0	2(2)	0	6(2)	21(15)
Lynx Take for Decade Two of Forest Plan (2014-2023) Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	**Total**
Vehicle[1]	1(1)	0	0	1 (1[3])	1(1[4])						3(3)
Other[2]	1(1)	1(0)	1(0)	1(1)	0						4(2)

*(Numbers in parenthesis indicate mortalities. The remainder was a non-lethal take)

1. Vehicle includes all motorized vehicles including cars, trucks, trains, ATVs and snowmobiles

2. Trapping, shooting and unknown causes

3. Photos submitted to MN DNR of injured lynx reportedly hit along a County Road within the Superior NF. No carcass recovered.

4. Photos submitted to MN DNR of an injured Canada lynx reportedly discovered along a snowmobile trail on the SNF. No carcass recovered

The 2011 BO recommends the following conservation measures for Canada lynx on the Superior National Forest (USDI 2011):

- Accurately inventory and monitor areas of regular cross-country over-the-snow travel (routes used most years, and for most of the snow season).

The Superior National Forest has not inventoried and is not currently monitoring over-the-snow travel. The Forest allows cross-country snowmobile travel.

- Co-location of ATV and snowmobile trails can be a benefit to lynx. Consider and co-locate where possible, ATV and snowmobile trails to ensure no net increase of snow compaction.

There has been little change to ATV or snowmobile trails on the Forest since 2004, except to co-locate some ATV trails on open Forest roads. This conservation measure is covered by standards and guidelines in the Forest Plan and is applied to all trail projects (USDA 2004; S-WL-2, G-WL-6, G-WL-7).

Work with the Service, States, and tribes to help reduce incidental take of lynx by trappers in Minnesota through ongoing outreach efforts and interagency cooperation.

The Forest Service maintains strong interagency communication regarding the incidental take of lynx. We notify the Fish and Wildlife Service of any lynx take occurrences we become aware of so that they may continually update their take database. The FWS, State, and tribes all receive copies of our annual DNA report that includes genetic information, reproduction, and distribution, as well as take information. The Forest requests that the State and tribes send us DNA samples of any incidentally taken lynx for inclusion in our DNA database.

Habitat Conditions

Most of the Superior National Forest represents critical habitat for the Canada lynx. Through vegetation management and limitations on roads, trails, or other developments, the Forest Plan promotes the maintenance or development of space, food, and cover sufficient or greater than sufficient to assure adequate habitat for the survival of the Canada lynx (USDA 2011). The Forest Service evaluates all components of lynx habitat --foraging, denning, connectivity, suitable acres, and access within spatial units referred to as lynx analysis units (LAUs). There are 47 LAUs on the Superior National Forest; one of these, LAU 47, is outside of critical habitat (USDA 2011). Lynx analysis units 44 (Gunflint Trail) and 46 (Virginia Unit) emphasize connectivity and travel habitat (USDA 2004).

Good foraging habitat for lynx equates to good habitat for their primary prey species, the snowshoe hare. Snowshoe hares use forested areas with dense understory vegetation for cover and food. Mature conifer or hardwood-conifer mixed stands, and stands between five and twenty years old, generally represent these conditions; whereas recently harvested areas (4 years or less in uplands; 9 years or less in lowlands) create unsuitable conditions.

Lynx foraging habitat on NFS lands in 2017 ranged from 39 percent to 79 percent across all the LAUs. Specialists predict these percentages to be similar in 2024 (table 5.15-9). Currently, an average of 59 percent of NFS lands meet the definition of foraging habitat, which is higher than the 42 percent prediction for decade 2 (table 5.15-9).

Appendix TE-2 of the M&E Report project file lists the changes in foraging habitat for individual LAUs between 2014 and 2024. In the second decade of the Forest Plan, snowshoe hare habitat has increased in some LAUs and decreased in others but is expected to change by less than 10 percent for most. LAU 24 shows the biggest habitat increase of 16 percent, while LAU 44 models the biggest expected decrease of -30 percent by 2024. In summary, more snowshoe hare habitat exists now and into the future than was predicted in the 2004 biological assessment (USDA 2004).

Table 5.15-9. Lynx foraging (snowshoe hare) habitat on NFS lands in acres (1,000s) and percent of total lynx habitat across all LAUs. Also the spread of conditions from LAUs with lowest to highest amounts of snowshoe hare habitats*

National Forest Decade/Year for Snowshoe Hare Habitat	All LAUs-Acres (1,000s)	All LAUs-Percent (%) of NFS lynx habitat	Spread: Individual LAUs with lowest to highest amounts of hare habitat Acres (1,000s)	Spread: Individual LAUs with lowest to highest amounts of hare habitat - Percent of NFS lynx habitat
Superior Current Habitat and Prediction for Decade 2: 2014	769.7	60	5.9-42.1	39 to 83
2017	749.4	59	6.0-39.9	39 to 79
2024	748.1	59	6.1-39.2	38 to 76
Decadal Habitat Predictions from the Forest Plan and 2004 Biological Assessment‡ Decade 1	602.6	48	5.2 to 30.4	13 to 55
Decade 2	521.3	42	3.3 to 24.8	12 to 42
Decade 5	373.0	30	3.2 to 19.8	10 to 30
Decade 10	399.9	32	2.3 to 20.5	7 to 42

*(See monitoring and evaluation report, project file)
‡Source: Dual plan – Planning Record. 2004 Biological Assessment

The Forest maintains abundant and well-distributed lynx denning habitat. Coarse woody debris, downed logs, or root wads are the common habitat component used by lynx for birthing and rearing young. Mature forest (age greater than 60) represents these kinds of conditions and the Forest uses them to model denning habitat.

Lynx denning habitat on NFS lands averaged 48 percent in 2017 and is expected to decrease to 44 percent in 2024 (table 5.15-10). Both percentages are higher than the 38 percent denning habitat predicted in the 2004 biological assessment for the second decade (USDA 2004).

The M&E Report project file lists changes in denning habitat for individual LAUs between 2014 and 2024. In the second decade of the Forest Plan (2014-2024), denning habitat increases in some LAUs and decreases in others but is expected to change by less than 10 percent for most. Lynx analysis unit 25 shows the biggest habitat increase of 11percent, while LAU 2 models the biggest expected decrease of -18 percent by 2024.

Table 5.15-10. Denning habitat acres (in 1,000s) and percent of lynx denning habitat on NFS lands across all LAUs

Total Denning Habitat in Patches Five Acres or Greater by Decade and Year	Acres (1,000s)	Percent (%)of NFS Lynx Habitat
Superior Current Habitat and Decade 2 Prediction[‡]: 2014	547.4	47
2017	552.9	48
2024	509.5	44
Decadal Habitat Predictions from the Forest Plan and 2004 Biological Assessment[‡]: Decade 1	475.3	42
Decade 2	429.5	38
Decade 5	216.3	19
Decade 10	502.0	44

[‡]Source: USDA 2004 BA

Lynx connectivity habitat refers to vegetation cover in sufficient quantity and arrangement, allowing lynx travel with ease long distances in search of food, cover, and mates. Both upland and lowland northern Minnesota forests typically have dense canopies and multi-storied structure providing cover. The forest models connectivity habitat by looking at the amount and distribution of upland forest greater than four years old and lowland forest greater than nine years.

Connectivity habitat on NFS lands averaged 88 percent in 2017 and is expected to increase to 89 percent in 2024 (table 5.15-11). Current predictions for connectivity habitat is slightly less than predicted in the 2004 BA. Research on long-distance movements of lynx on the Superior indicates good connectivity on the Forest and a general lack of barriers to lynx movement (Moen et al. 2010).

The M&E Report project file contains data on changes in connectivity habitat for individual LAUs between 2014 and 2024. In the second decade of the Forest Plan (2014-2024), connectivity habitat increases in some LAUs and decreases in others but is expected to change by less than 10 percent for most. Lynx analysis unit 24 shows the biggest habitat increase of 20 percent, while LAU 20 models the biggest expected decrease of nine percent by 2024.

Table 5.15-11. Acres (in 1,000s) and percent of connectivity habitat on NFS lands across all LAUs

Decade/Year for all LAUs	Acres (in 1,000s)	Percent (%) of NFS Lynx Habitat
Superior Current Habitat and Decade 2 Prediction: 2014	1,124	88
2017	1,119	88
2024	1,138	90
Decadal Habitat Predictions from the Forest Plan and 2004 Biological Assessment[‡]: Decade 1	1,197	96
Decade 2	1,196	96
Decade 5	1,195	96
Decade 10	1,200	96

[‡]Source: USDA 2004 BA

Unsuitable habitat for lynx includes areas in the initial stages of forest growth (early successional), where vegetation has not developed sufficiently to support snowshoe hare populations during all seasons. Unsuitable habitat is temporary and can result from natural disturbance or human management activities.

Forest Plan direction regarding unsuitable habitat for lynx includes the following:

- **S-WL-1:** Management activities on NFS land shall not change more than 15 percent of lynx habitat on NFS land within an LAU to an unsuitable condition within a 10-year period.
- **G-WL-3:** Limit disturbance within each LAU on NFS land as follows: if more than 30 percent of the total lynx habitat (all ownerships) within an LAU is currently in unsuitable condition, no further reduction of suitable conditions should occur from vegetation management activities by the national forest.

In 2017, the Superior National Forest adopted a standard approach to measure unsuitable habitat for S-WL-1 in the second decade of the Plan after consulting with the National Lynx Biology Team. This method uses a floating ten-year period prior to the start of any management activity. This approach is consistently used across the range of the lynx in the US and meets the intent of the 15 percent standard. For example, an analysis of unsuitable habitat in 2018 would include all forest stands treated from 2008 – 2018 that result in unsuitable habitat conditions.

Two LAUs are currently approaching the 15 percent threshold in 2024 with current planned activities: LAU 11 and LAU 18. Lynx analysis units 3, 7, and 42 are relatively high at 12 percent by 2024. Vegetation management planning carefully looks at these LAUs to stay below the 15 percent standard for activities. Lynx analysis unit 24 shows a high percentage of unsuitability in 2017 from the Pagami Fire but specialists expect it to drop to seven percent unsuitable by 2024. Information in the monitoring and evaluation report project file addresses the cumulative change in unsuitable habitat on National Forest System (NFS) lands by LAU for standard S-WL-1.

Most LAUs show less than three percent of lynx habitat as unsuitable when considering all ownerships. The Forest has no LAUS that have ever reached the 30 percent unsuitable limit. This is likely due to the high percentage of federal management for most of the Forest LAUs and that projects aim to protect and enhance lynx habitat. Information in the project file addresses unsuitable lynx habitat on all lands in 2017 as a measure of G-WL-3.

Human Disturbance/Access

Roads and trails may present several risks to lynx based on the potential for increased human use in lynx habitat (2004 BA Section 4.5.5.1). On NFS lands, land management activities and programs that most frequently result in human disturbances include road and trail building for management purposes, recreation management, and human developments such as mines. These disturbances and human access to lynx habitat may increase the potential for accidental or intentional trapping or shooting, disturbance at den sites, inter-specific competition with bobcats and/or coyotes for food; increased potential for predation from other carnivores, and lynx-vehicle collisions. Roads and trails are important to consider when evaluating gray wolf habitat for many of these same reasons.

The Forest uses NFS roads as indicators for lynx since low standard roads provide the greatest opportunity for human/wildlife encounters and less habitat security for lynx. Table 5.15-12 displays the existing (2017) and past (2004, 2014) Forest-wide miles of OML (operational maintenance level) 1 and 2 roads and temporary roads. Between 2004 and 2017 there has been an increase of three miles of OML 1 and an increase of 117 miles of OML 2 roads. There are fewer miles of OML1 roads than predicted with the Forest Plan and more miles of OML 2 roads; however, the current combined mileage of OML 1&2 roads is below the predicted combined totals for decades 1 and 2 by 152 to 354 miles. In addition to updates to roads database, these changes in road miles are a result of the Travel Management Rule that aligned the existing use of the road with the proper maintenance objective. In this process, some of the OML1 and unclassified roads were decommissioned and others moved to a higher maintenance level.

The U.S. Fish & Wildlife Service addresses potential effects of temporary roads to lynx and lynx critical habitat with project-level consultations. A formula estimates the number of temporary roads based on vegetation acres treated. This formula estimated 5.59 miles of temporary road per 1,000 acres of vegetation management treatments (USDA 2004 FEIS F-21).

Table 5.15-12. Estimated miles of temporary roads: OML 1 and 2 system roads

Decade/Year	Temporary Roads (Miles)	OML 1 Roads (Miles)	OML 2 Roads (Miles)
2004	432	816	1,031
2014	not calculated	816	1,158
2017	not calculated	819	1,148
Decadal Habitat Predictions from Forest Plan and 2004 Biological Assessment : Decade 1	754	1132	867
Decade 2	764	1,334	867
Decade 3	761	1,485	867
Decade 10	764	2,022	867

Source: USDA 2004a FEIS Appendix F-21, USDA 2004 BA and USDA 2011 (2010 data). 1

Forest Plan guideline G-WL-8 states, "Within LAUs generally maintain road and snow-compacting trail densities below 2 miles per sq. mile to maintain the natural competitive advantage of lynx in deep snow. Where total road and regularly-used snow-compacting trail densities are greater than 2 miles per sq. mile and coincide with lynx habitat, prioritize roads for seasonal restrictions or reclamation in those areas, where practical or feasible." In this guideline, "roads" include all ownerships of classified and unclassified roads and "regularly-used trails" are those used most years for most of the snow season. There are currently 33 LAUS out of 47 total with a road density less than 2 mi/square mile (table 5.15-13). Therefore, there is one more than the 32 LAUs reported in the 2011 BA (USDA 2011).

Table 5.15-13. Roads and compacted trail density on all ownerships

Forest-Wide LAU Conditions	# of LAUs	Land Area sq. miles	Total road miles	Av. miles per sq. mile
Existing road and compacted trail density summary (2017) : Below 2 miles per sq. mile	33	2,190	3,182	1.5
At or above 2 miles per sq. mile	14	787	2,014	2.5
Road and compacted trail density summary from 2011 BA[1]: Below 2 miles per sq. mile	32	2,032	2,865	1.4
At or above 2 miles per sq. mile	15	944	2,374	2.5

1Data source: Existing condition USDA 2011

The changes in road density for individual LAUs indicator includes all ownerships of classified and unclassified roads and trails used most years for most of the snow season. Lynx analysis unit 44 (Gunflint Trail) has the highest road density followed by LAUs 19, 34 and 46. The Forest continues to look for opportunities to decommission roads with each large vegetation

management project. Changes in road density for individual LAUs between 2014 and projected to 2024 based on decisions listed in appendix TE-2 in the M&E Report project file.

Since 2004, approximately 140 miles of road have been decommissioned (J.Rypka, pers. comm), and an additional 167 miles of roads are approved for decommissioning (J. Olson, pers. comm). The Forest expects additional habitat security for lynx in these LAUs once these road closures are complete. The Forest Plan objective was to decommission approximately 80 miles of road by 2014 (USDA 2004). The Travel Management Rule Decision allowed for the decommissioning of 154 miles of unclassified roads and provided a benefit to lynx by reducing road density and access in many LAUs (USDA 2009).

Objective RMV-1 of the Forest Plan states that a maximum of 90 additional ATV trail miles and 130 snowmobile trail miles may be added to the National Forest System. Since 2004, the Forest has added fourteen ATV trail miles. The increase in snowmobile trail miles since 2010 is a result of improvements to the database and not a result of adding new trails on the ground (project record, 2018). Two projects on the Forest, the Gunflint South Fowl EA and the Kawishiwi Trails Corridor EA, proposed new trail construction, decommissioning, and re-routing of trails and designating existing trails. There was a net reduction in snow-compacting routes reported for both of these projects. Additionally, both projects included a biological assessment and went through consultation with the USFWS. Trail miles on the Forest are still within the limits considered in the 2004 biological assessment.

Table 5.15-14. Existing (2017) and past (2010, 2004) miles of designated ATV and snowmobile trails on NFS and non-NFS lands within the Superior NF boundary[1]

Year/Decade 1	ATV Trails (Miles)	Snowmobile Trails (Miles)
2004	40	686
2010	40	705[1]
2017	54	794

1. Increase in miles reflects a correction to the 2004 BA and not an actual increase in miles (USDA 2011)

Population

Lynx population monitoring on the Superior National Forest includes snow tracking and collection of genetic samples, typically scat and hair. The DNA analysis on these samples helps document reproduction, relatedness, and persistence of lynx in Minnesota since 2002.

As of late September 2018, specialists have identified 379 individual lynx genotypes, of which 178 were females, 199 were males, and two were an undetermined sex. Of the 355 individuals that were not originally detected by mortality, 75 (21.1 percent) are known to have persisted into a second year. Additionally, specialists identified 43 samples as F1 lynx-bobcat hybrids with 13 unique genotypes: five female and eight male. There have been no F2 hybrids detected (Catton 2018).

Since 2010, specialists have identified 37 lynx family groups through a combination of field observations and DNA analysis. Of the 103 individuals identified as kittens in the database prior to winter 2017-2018, 31 (30.1 percent) have been recaptured into their second year or beyond and are assumed to have been recruited into the northeastern Minnesota subpopulation (Catton et al. 2018). During winter 2017-2018 survey season, DNA analysis confirms there were at least seven family groups with at least 16 kittens detected in the northeastern Minnesota survey and monitoring area.

As part of the delisting process for Canada lynx, the USFWS will convene an interagency team to develop a post de-listing monitoring plan. The Superior National Forest will participate in the development and implementation. Future monitoring and evaluation reports will provide more information as this effort gets underway.

Gray Wolf

The Federal ESA list removed gray wolves in the western great lakes (MN, WI, and MI) in 2007. However, on December 19, 2014 a federal court decision relisted them as threatened under the Endangered Species Act. The court upheld this ruling in August of 2017. Following the 2011 delisting, Minnesota allowed regulated wolf hunting during three hunting seasons, beginning with the 2012-13 season. The Superior National Forest falls within Minnesota's Northeast Wolf Zone, where the 2014 hunting season had harvesting of 41 wolves. Since relisting, wolf hunting is not allowed. The gray wolf is also a management indicator species (MIS) for the Superior National Forest.

Conservation Efforts

Maintaining and Improving Habitat

Vegetation management, and road and trail management maintains and improves gray wolf habitat. The Forest considers the habitat needs of wolves early in the planning process and carries consideration through project design and analysis. Landscape-scale vegetation projects create early successional forest and new growth providing benefits to prey species, specifically, deer and moose. Recent large vegetation projects with a focus on improving moose habitat include the Gunflint Shokoshoe and Lima Green EAs.

Following the Biological Opinion

The Terms, Conditions, Reasonable, and Prudent Measures of the biological opinion (BO) require the Forest Service to provide mortality reports to FWS and to work in partnership with other agencies to monitor wolf mortality (USDI 2011). The Fish and Wildlife Service expects "no more than 5 wolves would be taken annually on the Superior National Forest and no more than 50 due to vehicle collision over the remaining life of the plan on all roads and ownerships "(USDI 2011). "Take" includes to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. There were 17 records of road-killed wolves on the Superior NF between 2007 and 2015, with an annual take of zero to four (Catton 2016). Wolf take has not exceeded the limits outlined in the 2011 BO.

Habitat Conditions

Wolves are habitat generalists. Type, age, and structure of vegetation do not directly affect their distribution. However, in their northern Minnesota range, both within and outside of critical habitat, vegetation condition is important to their primary prey species: moose, white-tailed deer, and beaver.

Recovery plans discuss habitat management for wolf prey

The 1992 Federal Recovery Plan emphasizes increasing deer and moose populations. The 2001 State of Minnesota wolf plan does not emphasize increasing deer, but promotes maintaining "healthy populations" of these species. Rather than promoting high deer and moose populations for wolf alone, goals for balance to a variety of factors, including compatibility with habitats and

ecosystems, sustainable harvests for hunters, observation opportunities (aesthetics), and conflicts with humans such as vehicle accidents and crop damage are included.

The Forest used two habitat indicators to look at wolf prey habitat on the Forest:

1. Acres and percent of young upland forest less than 10 years old.
2. Acres and percent of upland conifer (spruce and pine) greater than nine years old.

Deer and moose use young upland forest as forage, and older conifer stands for thermal cover. Table 5.15-15 displays current and projected habitat conditions on the Forest, as well as the Forest Plan predictions by decade.

The 2018 analysis of habitat conditions for wolf shows less foraging cover for prey species than was predicted by the Forest Plan (table 5.15-15). This pattern is similar to the results displayed in the 2011 biological assessment and shared in consultation with the FWS. Foraging habitat for deer and moose (young upland forest) is likely higher than models predicted due to natural disturbances (fire, wind) and small forest gaps but is currently less than Forest Plan predictions. Thermal cover is projected to make up around 43 percent of upland forest by 2024, which matches with decade 2 predictions. There is currently no indication that prey availability is limiting wolf populations. Warming temperatures are likely to result in higher deer numbers and a continuing decrease in the moose population.

Table 5.15-15. Comparison and trends in forage and cover for wolf prey species

Year or Decade	Upland Forest (<10 yrs. old): Acres (1,000s)	Upland Forest (<10 yrs. old): Percent (%)	Cover (conifer > 9 yrs.): Acres (1,000s)	Cover (conifer > 9 yrs.): Percent (%)
Superior Current Habitat and Decade 2 Prediction : 2014	61.4	6.4	354.7	37.0
2017	48.0	5.0	360.5	37.8
Projected 2024	72.0	7.6	402.5	42.2
Superior Decade Habitat Predictions from 2004 Biological Assessment: Decade 1	100	10.4	371.3	38.7
Decade 2	101.7	10.4	411.7	43
Decade 5	97.7	10.2	531.0	55
Decade 10	94.2	9.8	554.0	58

Source: USDA 2004 Forest Plan Dual plan, USDA 2011 and 2018 modeling runs

Human Disturbance/Access

The 1992 Recovery Plan for Gray Wolf called for road density of high standard roads to remain below one mile per square mile in zones 1, 2 and 3. The Superior National Forest is predominantly in zones 1 and 2. The Forest Plan did not propose any changes to high standard roads so densities have remained essentially unchanged and are still below one mi/mi^2 (Table 5.15-16). Similarly, there has been relatively small (120 miles Forest wide) in low standard roads, road density, or in trails on the Forest since 2004. See the lynx section of this document for additional information on management of roads and trails.

Table 5.15-16. Density of high standard roads in 2017

Wolf Zone	Miles of High Standard Roads	Square Miles per Zone	Road Density
1	1,182	1,995	0.59
2	482	1,098	0.44
4	641	1,083	0.59
Forest-wide	2,306	5,889	0.39
Forest-wide w/o BWCAW	2,306	4,176	0.55

Displays 2018 modeling runs. High Standard Roads = USFS Roads OML 3, 4, and 5, US and State Highways and County and Township Road. Includes non-Forest Service roads

Population

Minnesota DNR wildlife officials conduct a wolf survey every winter and estimate population numbers by tracking radio-collared wolves and making estimates of average pack size. In 2018, the DNR also asked volunteers to report on wolf occupancy, which reassesses wolf distribution and range every five years. The 2018 survey reports 465 wolf packs with a range in total population from 1,972 wolves to 3,387 wolves. In addition, total wolf range increased by 18 percent between 2012 and 2018. Wolves remain widely distributed throughout Minnesota's forest zone (Erb 2018). Statewide wolf population numbers continue to exceed the 1,251 to 1,400-recovery goal and the Forest believes the wolf population on the Superior National Forest is stable or increasing.

Northern Long-eared Bat

Northern long-eared bat (NLEB) is a relatively recent addition to the Superior National Forest list of threatened species. On April 2, 2015, the USDI Fish and Wildlife Service listed the northern long-eared bat as threatened under the Endangered Species Act (USDI FWS 2015c). On January 14, 2016, the USDI Fish and Wildlife Service published a final 4(d) rule (effective 2/13/16) that provides flexibility to landowners, land managers, government agencies, and others as they conduct activities in NLEB habitat (USDI FWS 2016). The USFWS did not propose critical habitat for the species.

Conservation Efforts

Forest Plan, Conservation Measures and 4D Rule

The Forest Plan does not provide direction specifically addressing bats. It does however contain existing standards and guidelines that contribute to bat habitat conservation including direction to retain a variety of the largest diameter snags, cavity/den trees, and/or reserve trees in even-aged timber harvest areas, as well as riparian protections for ephemeral, intermittent, and perennial streams. This Forest Plan direction protects habitat suitable for northern long-eared bat roosting during the spring staging, summer, and fall swarming periods.

In addition to the Forest Plan standards and guidelines, the Forest Service's Eastern Region, in consultation with USDI FWS, developed additional conservation measures to implement with all new Forest Service projects as applicable and to minimize adverse impacts to the NLEB and other bat species, and to provide for the beneficial management of bat habitat. These include conservation measures identified in the Final 4(d) rule for the northern long-eared bat (USDI 2016), conservation measures from the Regional Programmatic BA (USDA FS 2015), and terms and conditions from the programmatic BO for Eastern Region National Forest (USDI 2015).

Under the 4(d) rule, incidental take involving tree removal in the WNS (white-nose syndrome) zone is allowable by following two conservation measures. The first measure is the year-round application of a one-quarter-mile radius buffer around known NLEB hibernacula. The second conservation measure involves the temporary protection of known, occupied maternity roost trees (USDI 2016). The Superior National Forest has been utilizing the 4(d) streamlined consultation form on all projects with decisions and following these two conservation measures.

Monitoring and Research

In 2009, the Superior National Forest began to collect baseline information on bats in anticipation of the devastating effects of WNS and as part of a larger region-wide effort. Six mobile acoustic transects were established across the Forest with the goal of sampling each transect three times each season. Figure 5.15-6 displays the annual runs the Forest has used since 2009.

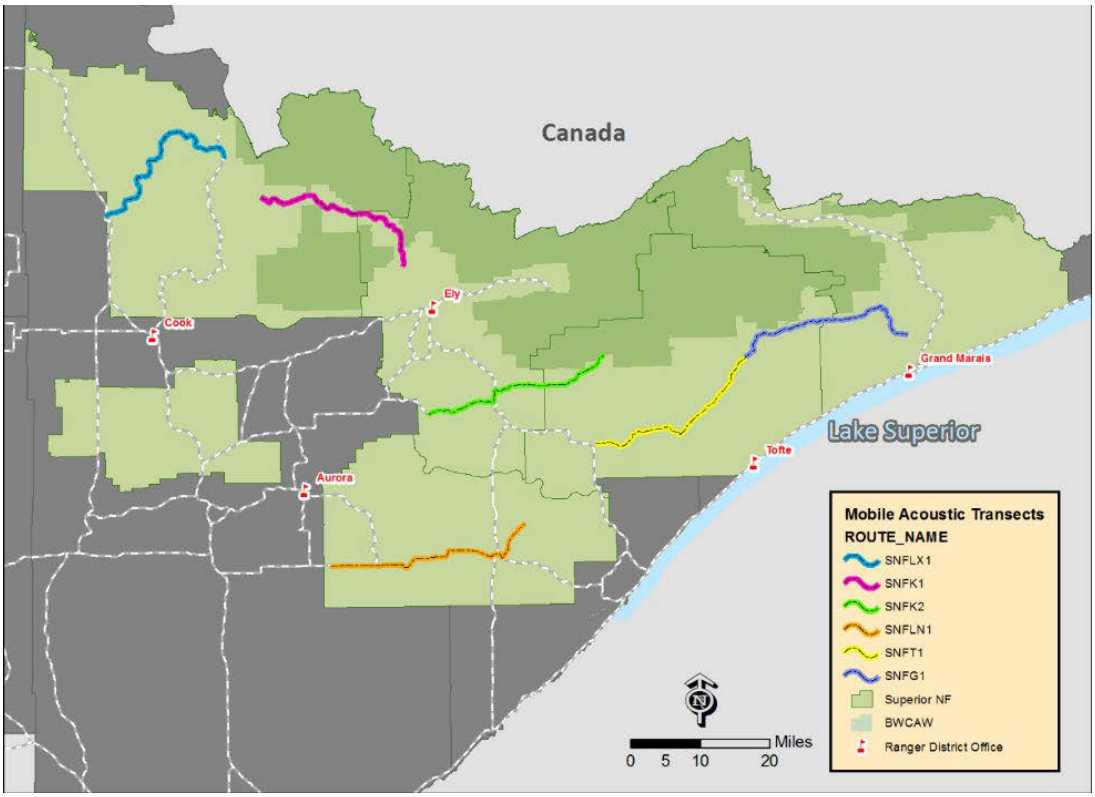


Figure 5.15-6. Mobile acoustic survey transects on the Superior National Forest

In 2013, the Forest began mist-netting surveys for bats responding to effects of WNS and augmenting the Forest's existing bat mobile acoustic survey transects. In 2015, the Forest collaborated with the MN DNR and the University of Minnesota-Duluth's Natural Resources Research Institute (NRRI) to conduct a statewide research project entitled "Endangered bats, white-nose syndrome and forest habitat." The project's purpose is to investigate roost site characteristics and summer habitat use by the northern long-eared bat, which recently was listed as threatened under the Endangered Species Act (USFWS 2015). Several project reports document the results of this multi-year partnership study on bats. (Catton and Kirschbaum 2018, Swingen et al. 2015, 2016, and 2017).

The multi-year Bats and Forest Habitat Study included mist-netting surveys, radio telemetry, emergence surveys, and additional acoustic surveys. The study selected mist-netting sites to target NLEBs. Researchers attached transmitters primarily to reproductive female NLEBs, and located roost sites using radio telemetry. Emergence surveys were conducted when and where possible. Roost tree measurements and surrounding habitat characteristics were recorded (Catton and Kirschbaum 2018, Swingen et al. 2015, 2016, 2017).

Bat Houses

Despite an abundance of summer roosting habitat, the Forest is installing bat boxes to enhance conservation measures, and promote public awareness for monitoring purposes. Currently, 29 bat houses exist across the Forest – most of these in public campgrounds or recreation facilities (table 5.15-17). Interpretive signs at some sites explain the concern for bats, white-nose syndrome and forest bat monitoring efforts. Visual inspections have indicated use by bats. The

Forest needs to conduct more monitoring of these structures to determine occupancy, level of use by bats, and conservation importance.

Table 5.15-17. Bat houses on the Superior National Forest

District	Number of Bat Houses	General Location
La Croix - Cook	1	District Office
Kawishiwi - Ely	10	Fenske, Fall Lake, Kawishiwi Ranger Station Kawishiwi Field Lab North Kawishiwi Field Lab South South Kawishiwi Campground Harris Creek, FR 178, One Pine, Nickel Lake
Laurentian - Aurora	11	Bird Lake, Cadotte campground, Guard Station Laurentian office, Laurentian Divide, Pfeiffer lake campground (2), Salo Lake, Whiteface campground (2), Lake Leander
Tofte	4	Tofte office, Sawbill Cabin Crescent Lake Campground Oberg,
Gunflint – Grand Maris	3	Gunflint Office. Pincushion, Two Island Campground

Environmental Education

Other conservation efforts include ongoing environmental education events to raise awareness and promote the conservation of bats. The Superior directs many of our programs towards families and the public. Some examples of these programs over the last few years include:

- "Northern Long-Eared Bat Legal Status and Agency Response" presentation to Ely Field Naturalists.
- "Ely's Gone Batty" event at Ely Folk School for kids and parents.
- Bat box-building events at Ely Folk School, North House Folk School in Grand Marais, Birch Grove School in Tofte, and AmericInn in Silver Bay.
- Evening campfire programs on bats as part of the North Shore Naturalist Programs.
- Interview with biologist about northern long-eared bat and white-nose syndrome on WTIP radio station in Grand Marais.
- Program for Minnesota Bat Festival (08/19/2017).

Forest staff also visit local schools to share information. Some examples of programs include:

- "Meet the Scientist" program for Ely 2nd and 4th grade classes highlighting bat research and conservation.
- Bat program for Duluth Denfeld High School SEAK event (Students Eagerly Acquiring Knowledge).
- "Be a Bat Biologist" for fifth graders in Cook, MN.

- "All about Bats" presentation and activities for fourth graders in Cook, MN.

Finally, the Forest is sharing the research and monitoring efforts with the scientific and business communities:

- Program for MN Power in 2014.
- Presentation at Forestry and Wildlife Research Review in 2016.
- Presentation at Bat Friendly Forestry in 2014.
- Poster at 2017 Joint Bat Working Group Annual Meeting.

Habitat Condition

The most significant range-wide threat to the NLEB and the primary reason for the listing by FWS is white-nose syndrome, a lethal fungal disease spread while the species inhabits caves during winter hibernation. Loss of suitable summer roost habitat alone is not likely to have significant population-level effects (USDI FWS 2015). Suitable summer habitat consists of a wide variety of forested/wooded habitats and possibly some adjacent and interspersed non-forested habitats (USDI FWS 2015). More than 86 percent of State and county lands provide suitable summer habitat for NLEB (USDA 2015). Forest specialists expect summer habitat to remain abundant and well distributed on the Superior National Forest (table 5.15-18).

The Bat and Forest Habitat research project provided new and exciting information on NLEB roost trees on the Superior National Forest. Results are preliminary but most bat roost trees from this study were live aspen with an average diameter breast height (dbh) of 15.1 inches (Catton and Kirschbaum 2018) Other tree species used by roosting bats included red maple, black ash, and white pine.

Table 5.15-18. Percentage of suitable summer forested habitat greater than nine years old for the northern long-eared bat on NFS lands under current and projected conditions

Forest Habitat Indicators	2014-Acres	2014-Percent (%)	2017-Acres	2017-Percent (%)	2024-Acres	2024-Percent (%)
Upland Forest > 9 years (MIH 1)	827,123	94	904,116	95	880,871	92
Lowland Forest > 9 years (MIH 9)	**206,950**	**98**	**208,121**	**98**	**208,116**	96

Population

Six of the eight species of bats known to occur in Minnesota were detected during mist-net survey activities on the Superior National Forest: big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), silver-haired bat (*Lasionycteris noctivagans*), little brown bat (*Myotis lucifiguous*), and the northern long-eared bat (*Myotis septentrionalis*). Acoustic detection located more species than were netting on 22 of the 32 mist-netting survey nights (68.8 percent) that acoustic detectors were used.

Sadly, in 2016, the Soudan Underground Mine confirmed the presence of white-nose syndrome there. This mine serves as the largest known hibernacula for Myotine bats in Minnesota. In reference to northeastern Minnesota bats, a 2017 news release states, "…a 73 percent decrease was observed at Soudan Underground Mine in St. Louis County, where the disease was first confirmed in Minnesota a year ago." Our monitoring results on the Superior show this same

pattern. Following the confirmation of WNS in bats in the Soudan Underground Mine (MN DNR 2016), capture success of both Myotis bats and all bats dropped significantly on the Superior National Forest (figure 5.15-7; Catton and Kirschbaum 2018). Forest staff observed this same pattern for *Myotis* species from the acoustic driving routes (figure 5.15-8). Continued monitoring will allow tracking on this decline and hopefully the recovery of the Forest's remaining bat populations.

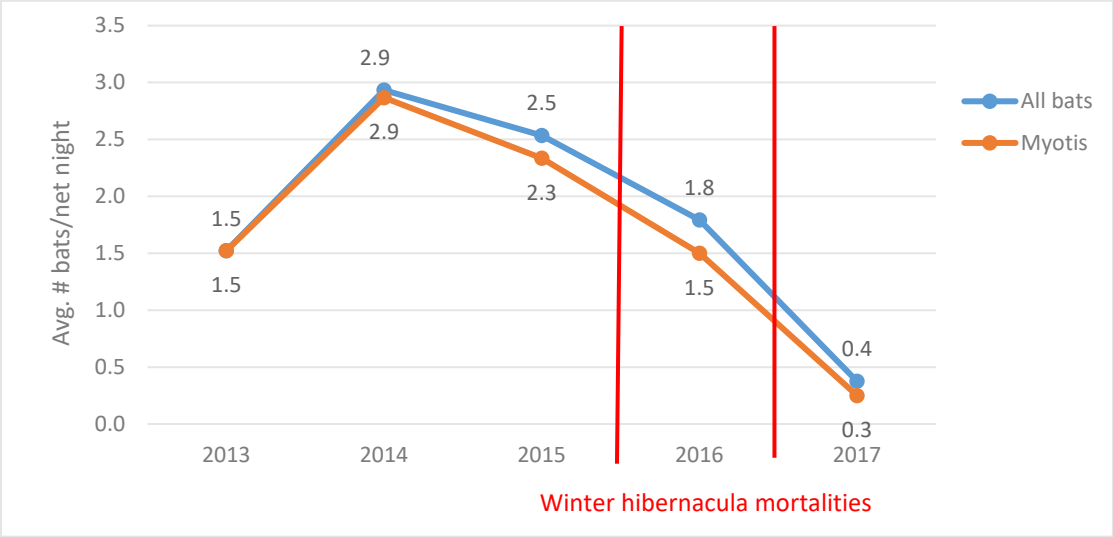


Figure 5.15-7. Average capture success of bats on the Superior NF, 2013-2017

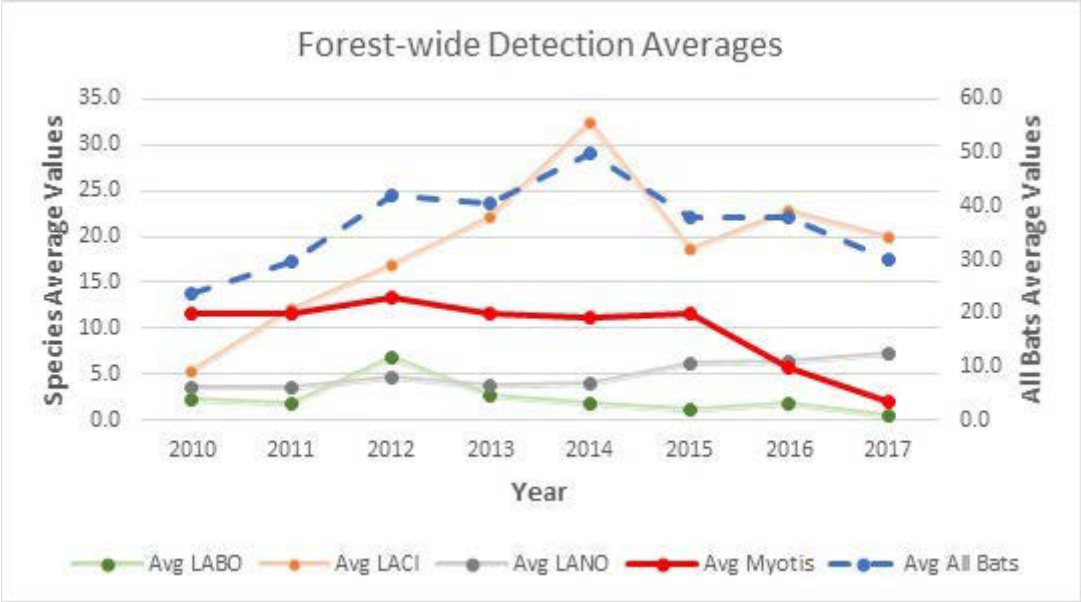


Figure 5.15-8. Average number of detections/survey transect/year for eastern red bat (LABO), hoary bat (LACI), silver-haired bat (LANO), average for all *Myotis* and average for all bats

Results and Analysis

To what extent are road and trail closures effective in prohibiting unauthorized motor vehicle use?

Low-standard closed or temporary roads have short-term impacts because these roads generally are closed when not in use. In addition, the Forest decommissions temporary roads after use is complete. The number of low-standard roads and their overall mileage will vary annually because of the number of operational management activities across the Forest. The Forest Plan requires the effective closure of these roads, especially where they intersect newly constructed trails so that motorized recreational use is limited to designated routes.

In 2009, the Forest evaluated the Nira Stewardship Project to determine the effectiveness of road closure methods used on the Forest to restrict large and small-motorized vehicle use. Twenty-two (81 percent) of the 27 closures were found to be very effective. At five sites, road obliteration was not completely successful due to the poor survival of planted woody vegetation. While most of these plantings were not successful at these five sites, the report concluded that the closures were still effective in keeping motorized use to a minimum (USDA 2009b).

Another road closure-monitoring project in 2011 looked at 45 closures across the Forest. Of roads reviewed, closure occurred on 93 percent with no evidence of motorized travel. The report also documents "considerable variability in the intensity and extensiveness of closure practices" (USDA 2011). More aggressive closure methods (e.g. rocks, berm, woody debris, gates) did not always prevent motorized access and increased the time for revegetation to occur.

The active monitoring of illegal user created motorized trails is ongoing (T.Mullins, pers. comm). Upon locating user-created trails, report their location and resource impact information to decision-makers and law enforcement.

Results and Analysis

To what extent is the Forest maintaining no net increase in groomed or designed over-the-snow trail routes unless the designation effectively consolidates use and improves lynx habitat through a net reduction of compacted snow areas?

See table 5.15-14 and related discussion on trails and human disturbance/access.

Results and Analysis

- Wolf density and population levels

See discussion under Gray Wolf Population.

Recommendations

Wildlife and their Habitats (General)

- Look for new tools, such as high density LIDAR, for measuring and monitoring fine-scaled habitat variables.
- Look for opportunities to use volunteers and Citizen Science to expand on species monitoring.
- Assess and prioritize existing monitoring efforts based on partner involvement, workforce capacity, and usefulness of results.
- Evaluate the current monitoring and determine any changes or additions because of emerging issues such as climate change and changes in intensity of forest management.

Management Indicator Species - Bald Eagle

- Look for opportunities, in partnership with the State, to complete another Forest-wide survey similar to 2005. While project-level surveys are useful for planning and implementing activities at the district level, they offer little insight into overall population trends.
- Focus efforts on caring, tending, and maintaining white pine that the Forest planted in the first and second decade of the Forest Plan. These trees will provide future nesting structures for bald eagles.
- Continue to move towards second decade objectives for white pine; specifically increasing the white pine component in the Mesic Red and White Pine Landscape Ecosystem and the Dry-Mesic Red and White Pine LE where the midpoint RNV value is 27 percent and 13 percent respectively (USDA FEIS Vol. 1 2004).
- Identify an annual metric for tracking on forest interplanting and underplanting of white pine. This provides a better understanding of young white pine on the Forest, as well as enhanced measuring of efforts to improve structure and diversity within stands.
- Look for project opportunities to plant white pine in riparian areas to provide nesting structures into the future.
- Look for ways to monitor young and mature white pine in the Boundary Waters Canoe Area Wilderness. Planting in the BWCAW may be necessary to provide future nesting structures if there is insufficient natural white pine regeneration.
- Focus habitat management by retaining large diameter trees in proximity to water. Bald eagles will use tree species other than white pine for nesting, including red pine and aspen, but choose the largest trees available in an area. (Grier and Guinn 2003).

Management Indicator Species - Northern Goshawk

- Continue with ongoing monitoring of known northern goshawk territories in partnership with the DNR.
- Continue and expand on DNA feather analysis. Look for partners in research and with the DNR to assist in answering questions about persistence, relatedness, and movement between territories.
- Refine methods of classifying mature forest stands and mature upland patches. There is a need to improve our method of measuring canopy cover using remote sensing tools such as high density LiDAR and to relate these conditions to goshawk habitat use. Improve our habitat suitability models by using these results. Respond to the need to improve our understanding of how goshawks adapt to habitat changes within their nesting, post-fledging, and foraging areas. Develop and implement a method for monitoring habitat changes around known goshawk territories and monitor goshawk response pre and post treatment.
- Conduct a simple analysis of known nest sites and associated MIH type to determine the usefulness of MIH4 (aspen and aspen-conifer) as a predictor variable.

Regional Foresters Sensitive Species

- Continue to meet RFSS designation criteria of currently listed terrestrial RFSS that warrant continued survey and monitoring efforts.
- Continue future work and assessment of boreal owl, taiga alpine butterfly, Frejia's grizzled skipper, and tri-colored bat. These species have experience no change in the number of

occurrences. They require additional efforts to determine if these species warrant an increase in survey and monitoring effort.

- Provide a detailed species-by-species evaluation of the current situation and monitoring results for each species in the next monitoring and evaluation report.

Improve Roads and Trail Monitoring

There is a need to improve our roads and trails database for increased accuracy of ground conditions. For example, vegetation has overgrown some system roads so road effects on wildlife would be minimal. Alternatively, there are user developed trails that may be unaccounted for as part of our road/trail network. There needs to be consistency across the Forest in in updating and maintaining the roads database (INFRA).

Forest Plan implementation effectively closes temporary roads after completing management activities, with minimally assumed effects to wildlife. There is currently no Forest-wide methods for tracking the amount of annually constructed temporary roads. The Forest needs more monitoring to determine if the Forest is within the decadal mileage for temporary road miles projected by the Forest Plan, and if closures are effective. Is the assumption of 5.59 miles of temporary road per 1,000 acres of vegetation management treatments still valid? (USDA 2004 FEIS F-21)

The Forest needs to develop a process to monitor and track temporary roads associated with minerals exploration and development. This is a growing Forest demand and these roads may be open and drivable for a longer period than roads associated with timber sales. The Prospecting Permit EIS, record of decision, and biological assessment contains one recent analysis of these impacts. (USDA 2012).

There is a need to monitor special use roads – especially effectiveness monitoring of road closures. Often, a different agency or individual is responsible for the road closure after completing management activities. These closures should follow the same standards applied to other roads on the Forest.

Proactive Planning for Increased Recreation and Special use Demands

There is a need to take a Forest-wide look and consider the cumulative effects on wildlife resulting from increased recreational disturbance. The number of recreationists on the Forest continues to grow each year. Newer sports, such as fat tire bicycling, brings more people into contact with wildlife at all times of the year. It may be important to designate areas where we will limit disturbance to provide habitat security for species like lynx and wolf.

There is a need to take a comprehensive look at special uses and effects on wildlife. For example, the Forest is aware of at least one case where baiting was used to attract lynx for wildlife photography and tourism. In addition, large-scale sugar bush operations are on the rise. Impacts to wildlife from these are largely unknown and should be studied and monitored. There is currently a Forest-wide effort to review special uses and document site-specific concerns.

Canada Lynx Habitat

Continue with Canada lynx DNA collection to monitor changes in occupancy, persistence, and reproduction on the Forest.

The understory vegetation; specifically the density of balsam fir, is very important in determining the presence of snowshoe hare, the primary prey species of lynx. Yet, Forest habitat models use overstory forest type and age. The Forest needs to develop new habitat models that incorporate the understory. This is also important given the increased target for fuels and the likelihood of more understory fuels reduction on the Forest, which can have negative impacts to habitat suitability for lynx.

Improve our understanding and modeling of snowshoe hare habitat; including the importance of habitat connectivity as it relates to local snowshoe hare populations.

Across the Forest, continue to look for opportunities to decommission roads project areas for each large vegetation management project.

Lynx Analysis Units 3, 7, 11, 18 and 42 are nearing 15 percent unsuitable habitat for lynx. The Forest needs to be careful not to exceed the standard for lynx habitat when planning vegetation management activities in these areas.

Continue to look for ways of measuring habitat changes on non-NFS lands and the less than 30 percent unsuitable guideline (G-WL-3).

Northern Long-eared Bat

Continue with mobile acoustic survey transects to monitor changes from WNS to local bat populations. Add one NABAT transect to each side of the Forest to contribute to national and regional monitoring efforts.

Across the Forest, 29 bat houses have been installed; however, there has been very little monitoring of their use. Emergence surveys would provide us with important information on bat numbers and species using these structures for roosting.

- There is a need for more inventory and monitoring of structures used by bats. This is especially important given the likelihood of listing of that Little Brown Bat. New Species of Concern since 2004

Data on pollinators is limited across the Forest. In 2017, the State of Minnesota listed the Rusty Patched Bumblebee as endangered. There are currently no known populations on the Forest, so consultation with FWS for this species is not required at this time. In 2014, the FWS began a species status assessment to determine if the Monarch Butterfly warrants listing under the Endangered Species Act. There are growing concerns for pollinators and continued monitoring of this important group of insects will provide information in the event of future listings.

References

Baker, R. and Monstad, Y. 2006. 2005 Minnesota Bald Eagle Surveys. Minnesota DNR, St. Paul, MN. 3 pg.

Bednar, J.D., N.G. Walton, A.R. Grinde, G.J. Niemi. 2016. Summary of breeding bird trends in the Chippewa and Superior National Forests of Minnesota – 1995-2016. NRRI technical report NRRI/TR-2016/36, University of Minnesota Duluth.

Bruggeman, J. 2011. Northern goshawk monitoring in the Western Great Lakes Bioregion. The Journal of Raptor Research. 45(4):290-303.

Catton, T. J. 2018. Preliminary analysis of the Superior National Forest's mobile acoustic surveys for bats 2010-2017 DRAFT (unpublished).

Catton, T. 9/17/2018. Email to Peg Robertsen with update on lynx DNA monitoring results.

Catton, T. 9/12/2018. Lynx families in 2017/2018. Email to Peg Robertsen with attachment.

Catton, T. and K. Kirschbaum. Draft 08/16/2018. Summary report of mist-netting surveys for bats on the Superior National Forest 2013-2017.

Catton, S. 2016. Email to Susan Catton from Dan Stark, MN DNR, summarizing road-killed lynx and wolf numbers from 2007-2016.

Cochrane, M.M., D.J. Brown, M.D., Nelson, R.R. Buech, M. Schrage, D. Ryan, and R.A. Moen. 2018. Status of a wood turtle (Glyptemys insculpta) population in northeastern Minnesota. Herpetological Conservation and Biology.

Crozier G. and Hamady, M. 2018. Minnesota Wood Turtle Final Report: Upper Midwest Riverine Turtle Habitat Improvement Project. Competitive State Wildlife Grant MN F14AP00028, November 7, 2013 – September 30, 2017.

Crozier, G. 2018. Data consolidated from Excel workbook and shapefile provided by Gaea Crozier MNDNR, email dated 1/18/2018 "2017goshawk monitoring results".

DelGiudice, G.D. 2018. 2018 Aerial moose survey. Minnesota Department of Natural Resources, Section of Wildlife, unpublished report. St. Paul, USA. 7pp.

Erb, J., C. Humpal, and B. Sampson. 2018. Distribution and abundance of wolves in Minnesota, 2017-18. Minnesota Department of Natural Resources, Grand Rapids, MN, 12 p.

Grier, J. and J. Guinn. 2003. Bald eagle habitats and responses to human disturbance in Minnesota. Final report to MN DNR, 48 pg.

Grosshuesch, D.A. 2018 Western Great Lakes Rare Owl Surveys - Minnesota data (D.Grosshuesch email 9/10/2018, unpublished data).

Hawk Ridge Bird Observatory. Western Great Lakes Owl Monitoring Reports 2005-2014. Available at https://www.hawkridge.org/research/western-great-lakes-owl-monitoring/. Accessed October 2018.

Interagency Lynx Biology Team. 2013. Canada lynx conservation assessment and strategy. Third edition. USDA Forest Service, USDI Fish and Wildlife Service, USDI Bureau of Land Management, and USDI National Park Service. Forest Service Publication R1-13-19, Missoula, MT. 128 pp.

Jannett, F.J. Population Dynamics of Small Mammals on the Superior National Forest. Various reports 1990-2016.

Koch, K., D. Moody, S. Michaile, M. Magana, M. Fitzgibbon, G. Rowell, T. Will and G. Ballard. 2010. The Midwest Avian Data Center. [Web application]. Petaluma, California. http://data.pointblue.org/partners/mwadc. (Accessed: October, November 2018).

Lane, W.H., 2010 Owl Survey, Preliminary Report.

MNDNR Biotics database 2017. The Natural Heritage Information System, Natural Heritage & Nongame Research Program of the Minnesota Department of Natural Resources, Division of Ecological Services.

Minnesota Department of Natural Resources [MN DNR]. 2016. First case of white-nose syndrome, a disease that can kill bats, confirmed in Minnesota. News Release March 9, 2016.

Moen, Ron. Lauren Terwilliger, Alan Dohmen and Susan Catton. 2010. Habitat and road use by Canada lynx making long-distance movements. Center for Water and Environment Natural Resources Research Institute. University of Minnesota-Duluth, USDA Forest Service, Superior National Forest. Duluth, MN

Mullins, T. 2018. Email providing summary of citations for illegal use of trails and recreational vehicles from 2004-2018.

Murray, K.L. and T. Hohoff. 2015. Findings Report: Bat Acoustic Analysis. Superior National Forest 2009-2014. Prepared for the Superior National Forest, Duluth, MN. Prepared by Western Ecosystems Technology, Inc. (WEST), Bloomington, Indiana.

Naumen, L. June 10, 2017. Minnesota's Bald Eagle population soars above most of the United States. Star Tribune article.

NatureServe. 2018. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: September 22, 2018).

Natural Resource Manager (NRM) Wildlife application. USDA Forest Service, Current version 2.14.0. Accessed August, September 2018.

NRRI Forest Songbird Monitoring map of detections 1991-2017

North American Butterfly Association (NABA) Circle Count, 2018 unpublished data. Data provided by G. McCormick, D. MacLean, W. Mattson and J. Sanders.

Pfannmuller, L., G. Niemi, J. Green, B. Sample, N. Walton, E. Zlonis, T. Brown, A. Bracey, G. Host, J. Reed, K. Rewinkel, and N. Will. 2017. The First Minnesota Breeding Bird Atlas (2009-2013). Data accessed online via the Midwest Avian Center http://data.pointblue.org/partners/mwadc

Pilgrim, K and M.Schwartz 2014. DNA Analysis of northern goshawk (*Accipiter gentilis*) feather samples collected in northern Minnesota by the Superior National Forest 2013. Unpublished Report, 4 pg.

Pilgrim, K and M.Schwartz 2013. DNA Analysis of northern goshawk (*Accipiter gentilis*) feather samples collected in northern Minnesota by the Superior National Forest 2013. Unpublished Report, 7 pg.

Sauer, J. R., D. K. Niven, J. E. Hines, D. J. Ziolkowski, Jr, K. L. Pardieck, J. E. Fallon, and W. A. Link. 2017. The North American Breeding Bird Survey, Results and Analysis 1966 - 2015. Version 2.07.2017 USGS Patuxent Wildlife Research Center, Laurel, MD

Schrage, M. 2018. Aerial moose survey spatial data. Fond du Lac Resource Management Division., unpublished. Cloquet, MN

Swingen, M., R. Baker, T. Catton, K. Kirschbaum, G. Nordquist, B. Dirks and R. Moen. 2015. Preliminary Summary of 2015 Northern Long-eared Bat Research in Minnesota. NRRI Technical Report No. NRRI/TR-2015/44, 12 pp.

Swingen, M., R. Baker, T. Catton, K. Kirschbaum, G. Nordquist, B. Dirks and R. Moen. 2016. Summary of 2016 Northern Long-eared Bat Research in Minnesota. NRRI Technical Report No. NRRI/TR-2016-, 15 pp.

Swingen, M., R. Moen, R. Baker, G. Nordquist, T. Catton, K. Kirschbaum, B. Dirks and N. Dietz. 2017. Summary of 2017 Bat Research in Minnesota. NRRI Technical Report No. NRRI/TR-201740, 19 pp.

USDA Forest Service (USDA FS)

2018. Final 2017 Regional Forester Sensitive Species List. Eastern Region Forest Service, Milwaukee, WI. January 8, 2018.

2015a. Biological Assessment of Effects to Northern Long Eared Bat from the Implementation of On-Going Timber Harvest, Tree Removal for planting or Fuels Reduction, and Prescribed Burning Projects (2015-2027) on the Superior National Forest. Superior National Forest, Duluth, MN.

2015b. Programmatic Biological Assessment- Northern Long-eared Bat- for Land and Resource Management Plans of the Forest Service Eastern Region. Eastern Region Regional Office, Milwaukee, WI.

2011. Programmatic Biological Assessment for Federally Listed Species: Gray wolf, Canada lynx, and their critical habitats for the Superior National Forest. Superior National Forest, Duluth, MN.

2011. Monitoring of road closure projects within vegetation treatment areas on the Superior National Forest. Nov. 2011. Unpublished internal report.

2009. Nira Road Decommissioning - 09/22/2009. – Unpublished internal report. B. Anderson – Forest Monitoring Coordinator. USDA-Forest Service, Superior National Forest, Supervisors Office. Pers. com.

2009. Forest-wide Travel Management Project Environmental Assessment Decision Notice. Superior National Forest, Duluth, MN.

2009. Superior National Forest Resource and Monitoring Report for Management Indicator Species (MIS). Duluth, MN, 11 pg.

2004a. Forest Plan Revision Biological Assessment. Superior National Forest, Duluth, MN.

2004b. Land and Resource Management Plan a.k.a. Forest Plan). Superior National Forest, Duluth, MN.

Most USDA Forest Service, Superior National Forest Plan Revision documents are available at http://www.fs.usda.gov/main/superior/landmanagement/planning

USDI Fish and Wildlife Service (USDI FWS)

2017. Current white-nose syndrome occurrence map. Accessed August 22, 2017 at: http://whitenosesyndrome.org/about/where-is-it-now

2016a Final 4D rule for the Northern long-eared bat. Federal register Vol 81, No.9. January 14, 2016. http://www.fws.gov/Midwest/endangered/mammals/nleb/pdf/FRnlebFinal4dRule14Jan2016.pdf

2016b. Programmatic Biological Opinion on Final 4(d) Rule for the Northern long-Eared Bat and Activities Excepted from Take Prohibitions. January 5, 2016. http://www.fws.gov/midwest/endangered/mammals/nleb/bos/16_NLEBRange_Final4d01052016.pdf

2016. Analysis of long-term forest bird monitoring data from national forests of the Western Great Lakes Region.

2015a. Biological Opinion for activities affecting the Northern Long-eared Bat on Eastern Region National Forests. Nov. 12, 2015.

2015b. Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Northern Long-Eared Bat With 4(d) Rule. Federal Register, April 2, 2015. Available at http://www.regulations.gov, search ID: FWS–R5–ES–2011–0024, 4500030113.

2015c. Biological Opinion of Effects to Northern Long Eared Bat from the Implementation of On-Going Timber Harvest, Tree Removal for planting or Fuels Reduction, and Prescribed Burning Projects (2015-2027) on the Superior National Forest. On file at Superior National Forest, Duluth, MN.

2011. Biological opinion for the Revised Land and Resource Management Plan for the Superior National Forest. On file at Superior National Forest, Duluth, MN.

2009. Post-delisting Monitoring Plan for the Bald Eagle (*Haliaeetusleucocephalus*) in the Contiguous 48 States. U.S. Fish and Wildlife Service, Divisions of Endangered Species and Migratory Birds and State Programs, Midwest Regional Office, Twin Cities, Minnesota, 75 pp.

1992. Recovery Plan for the Eastern Timber Wolf. Twin Cities, Minnesota.

Walton, N.G. et al. 2017. Summary of breeding bird trends in the Chippewa and Superior National Forests of Minnesota – 1995-2017. NRRI/TR-2017/30.