CHAPTER 1
PURPOSE AND NEED

Introduction

The Baldwin-White Cloud (BWC) Ranger District of the Huron-Manistee National Forests (HMNF) has proposed various management activities in the Bigelow-Newaygo Project on National Forest System (NFS) lands within the Bigelow-Newaygo Project Area (Project Area). The Bigelow-Newaygo Project proposes the following vegetative treatment activities: red pine thinning, overstory removal harvesting, opening creation, opening restoration/maintenance, savanna restoration, and broadcast burning. Additional vegetative treatment activities include: mechanical and manual woody vegetation removal, woody vegetation herbicide treatment, prescribed burning, native plant seeding, site preparation, and habitat protection measures. In addition road system activities and other miscellaneous activities are also proposed. The latter includes riparian habitat improvement; repairing resource damage, such as off-road vehicle (ORV) damage and illegal dumping; and, the treatment of non-native invasive plant species (NNIP).

This Environmental Assessment (EA) is a site-specific analysis of the proposed activities. It discloses the direct, indirect, and cumulative environmental effects of implementing the Proposed Action, the Action Alternative developed following public scoping, and the No Action Alternative. An interdisciplinary team (IDT) of Forest Service managers and specialists prepared this EA (see Chapter 4).

Project Location and Size

The Project Area (see Map 1 at the end of this chapter) is located on the BWC Ranger District of the HMNF in the following locations:

- T13N, R10W, Section 30 of Aetna Township, Mecosta County, MI
- T12N, R10W, Section 20 of Reynolds Township, Montcalm County, MI
- T12N, R11W, Sections 13, 30, and 31 of Croton Township, Newaygo County, MI
- T12N, R12W, Sections 1-4, 8-10, 25-27, and 34-36 of Brooks Township, Newaygo County, MI
- T13N, R11W, Sections 30-32 of Big Prairie Township, Newaygo County, MI
- T13N, R12W, Sections 22, 23, 27, 34, and 35 of Everett Township, Newaygo County, MI

The Bigelow-Newaygo Project Area occurs within compartments 513, 517, 519-522, 573, 576, 578, 582, and 586 of the BWC Ranger District. The Project Area totals approximately 31,911 acres. Approximately 7,676 acres (24% of total) are NFS lands, of which approximately 2,767 acres (36% of NFS acres and 9% of total acres) would be treated in the Proposed Action. The remaining approximately 24,235 acres (76% of total) are in private ownership.

Management Direction

The Bigelow-Newaygo Project EA is tiered to the 2006 Huron-Manistee Land and Resource Management Plan as Amended (Forest Plan) (HMNF 2006a) and Final Environmental Impact Statement (HMNF 2006b). Relevant discussions from these documents are incorporated by

reference rather than repeated (40 CFR 1502.21). A portion of the Project Area occurs within the HMNF's Old Growth design. The Bigelow-Newaygo Project activities would be consistent with HMNF's Old Growth Standards and Guidelines (USDA 1995).

The management prescription areas (MA) of the Project Area are primarily in MA 4.4 with lesser areas in MA 8.2, MA 8.3, MA 8.4, and MA 9.2W. Management directions for these areas are outlined in the Forest Plan Standards and Guidelines pages III-4.4-1-8 (MA 4.4), III-8.2-1-6 (MA 8.2), III-8.3-1-5 (MA 8.3), III-8.4-1-4 (MA 8.4), and III-9.2-1-4 (MA 9.2).

Management Area 4.4 (Rural) – According to the Forest Plan (pp. III-4.4-1), management activities provide recreational opportunities, sources of firewood close to users, and moderate to high volumes of softwood timber products. Emphasis includes reducing life-threatening and property-damaging wildfire potential. Wildlife management is coordinated with adjacent non-National Forest land management with emphasis on deer, grouse and other wildlife. Some small blocks of Federal land will be managed to protect isolated, essential areas for endangered, threatened or sensitive species.

Goals and Objectives for MA 4.4 include: maintain or increase wildlife habitat diversity, emphasize hazardous fuels treatment in the wildland urban interface and intermix areas, provide improvements for fish habitat, manage permanent openings and/or grasslands to meet species viability needs, manage for mesic grassland habitats, and create dry sand prairie habitat on Sparta soils series.

Management Area 8.2 (Research Natural Areas) – According to the Forest Plan (pp. III-8.2-2), management of designated Research Natural Areas (RNA) will protect unique areas that have scientific, biological, geological or historical characteristics of local, regional or national significance.

Goals and Objectives for MA 8.2 include: maintain the characteristics of each RNA for which they were designated. The approximately 180 acres of the Newaygo Prairies RNA is within the Project Area.

Management Area 8.3 (Experimental Forests) – According to the Forest Plan (pp. III-8.3-1), management of designated Experimental Forests will provide a land base for research activities.

Goals and Objectives for MA 8.3 include: The Experimental Forests will be managed as a roaded natural setting and provide a variety of management activities so that research opportunities exist to evaluate the effects of management practices. The approximately 460 acres of the Newaygo Experimental Forest is within the Project Area.

Management Area 8.4 (Special Areas) – According to the Forest Plan (pp. III-8.4-2), management of Special Areas will protect areas that have scientific, biological, geological, historical, social, or recreational characteristics of local, regional, or national significance.

Goals and Objectives for MA 8.4 include: maintain the characteristics of each area for which it was identified. The Special Area within the Project Area is the approximately 80 acres of the Newaygo Prairie Ecological Study Area.

Management Area 9.2W (Study Wild and Scenic Rivers/Wildlife Emphasis Area) – According to the Forest Plan (pp. III-9.2-1), these are lands in holding until studies and environmental

documentation for designation are completed. Management activities provide for Wild and Scenic River attributes and values.

Goals and Objectives for MA 9.2W include: maintain the unique characteristics of each river for which they were identified. The Wildlife Emphasis Area is the approximately 2,200 acres of the Croton Prairie, within the Little Muskegon Study Wild and Scenic River.

The objective for the Project Area is that management activities would implement the Standards and Guidelines of the HMNF's Forest Plan along with addressing land management issues or concerns. In addition, the development of this EA considers all pertinent environmental laws, regulations, and national direction.

Three old growth stands are being proposed for treatment as allowed for in the HMNF's Forest Plan (Forest Plan II-9). According to the Forest Plan, restoration treatments are allowed in old growth stands, including but not limited to, burning and mechanical treatments. The treatments in the Project Area include harvesting, woody vegetation treatment (such as mechanical and manual woody vegetation removal, and woody vegetation herbicide treatment), and other management activities to create savanna habitat (such as prescribed burning, native plant seeding, and site preparation).

Purpose and Need

The Purpose and Need for a project is arrived at by addressing the differences between the existing condition and the desired future condition. All management activities that occur within the HMNF are directed by the Forest Plan. The Forest Plan identifies how different areas of the HMNF are to be managed. The Purpose and Need of the Bigelow-Newaygo Project is to:

- Restore and maintain savannas, prairies, dry grasslands, and mesic grasslands where they were known to previously occur for habitat diversity and to meet species viability needs; manage wildlife and fisheries habitat; and manage native plant communities;
- Maintain viable populations of existing native and desired non-native species;
- Reduce life-threatening and property damaging wildfire potential; and,
- Provide recreational opportunities while protecting the unique ecosystem characteristics of the Project Area.

Treatments are proposed to address the Purpose and Need and accomplish the following objectives:

Restore and maintain savannas, prairies, dry grasslands, and mesic grasslands where they were known to previously occur for habitat diversity and to meet species viability needs.

Existing Condition: Historically, the Project Area was a mix of grassland, dry sand prairie, oak savanna, and woodland. Today's ownership is a patchwork of private and public lands with much of the prairie and savanna existing as remnants as a result of lands being converted to agricultural and residential uses, and natural succession. The uniqueness of the Project Area is demonstrated by the variety of MAs, including the Newaygo Prairies RNA, the Newaygo Experimental Forest, the Newaygo Prairie Ecological Study Area, and the Croton Prairie Wildlife Emphasis Area.

Desired Condition: The Project Area moves toward the reestablishment of the habitat types historically found in the area, i.e. grassland, prairie, and savanna. Upland openings, grasslands, and existing prairies are restored, expanded, and maintained. Other areas that contain the soils and plant species that are indicative of these habitats, which are now woodlands, would begin to be converted during this project to grasslands, prairies, and savannas, building on and expanding existing remnants.

The management of these existing land types, and the creation of additional areas, would benefit both rare and sensitive plant and animal species, especially the federally endangered Karner blue butterfly (KBB), as well as Regional Forester's Sensitive Species (RFSS) such as prairie smoke, lanceleaf coreopsis, eastern box turtle, hill-prairie spittlebug, and red-headed woodpecker.

Further enhancement of these habitats in the Project Area would be accomplished by addressing existing resource damage caused by ORVs and dumping, and reducing the potential for future resource damage by managing the existing transportation system. In addition, the presence of NNIP, which threatens the native plant species of the Project Area, would be reduced.

Need: There is a need to enhance, and in some cases create, prairie and savanna habitat in the Project Area. The Project Area historically contained a wide diversity of habitat types including a larger proportion of prairie and savanna than presently exists. Currently, plant and animal species that rely on these types of habitats are present in the Project Area, but need ecosystem enhancement activities to increase the viability of these rare species.

Wildlife and fisheries habitat, and native plant communities will be managed to maintain viable populations of existing native and desired non-native species.

Existing Condition: As described above, historically much of the habitat in the Project Area was grasslands, prairies, and savannas. The soil types that supported these habitats, and some of the animal and plant species that existed on these habitats, are still present in the area as remnant populations. Endangered species, especially the KBB, are present in the area both on public and private lands in widely scattered and disconnected habitats. Plant species, such as prairie smoke, western silvery aster and bird's foot violet, that are indicative of these historic land types, are still present in the area. However, due to the reduction in the size and distribution of their habitats, they are small in number and widely scattered across the Project Area.

Bigelow Creek is a high quality stream that currently is lacking certain important characteristics of a healthy aquatic ecosystem, such as instream woody debris, and the appropriate quantity and quality of shade trees in the riparian area. There are road stream crossings in the area that are impacting natural resources in the area and need to be improved.

Desired Condition: The Project Area moves toward the reestablishment and expansion of historic habitat types and the wildlife and plant species associated with them. Upland openings, grasslands and existing prairies, are restored and maintained providing important habitat conditions for plant species that are integral parts of the ecosystem. Other areas that currently exhibit the soils and plant species that are indicative of these habitats, but which are now woodlands, would begin to be converted to grasslands, prairies, and savannas, providing additional habitat for important plant and animal species.

The establishment of savanna habitat across the Project Area would provide habitat for the federally endangered KBB which now exists in widely scattered and isolated populations. This

habitat would provide important corridors for the butterfly and allow expansion of the population into currently unoccupied habitat created on public lands.

A stretch of Bigelow Creek that flows through the northern part of the Project Area contains a number of instream structures that will either be replaced or repaired restoring their functionality and providing important aquatic habitat. In addition, various tree species would be planted in the riparian corridor to supply a future population of shade trees integral to the functioning of a high quality trout stream. Road-stream crossings that are determined to be impacting natural resources are reconstructed.

Need: Similar to the need outlined for the previous purpose and need. Rare and unique ecosystems, on which important plant and animal species rely, are in need of enhancement in the Project Area. The current instream structures of Bigelow Creek require maintenance to improve stream habitat, health and diversity. In addition, riparian planting and road-stream crossing improvements would also enhance riparian habitat function and aquatic ecosystem health. Multiple road-stream crossings in the Project Area are negatively impacting natural resources.

Reduce life-threatening and property damaging wildfire potential

Existing Condition: Currently the Project Area is a mix of public lands and developed private property. This interface of developed and undeveloped lands is called the wildland urban interface. Because of the increase in human use in the area, the area has an increased potential for both human-caused fires and more damaging fire behavior from naturally occurring or human-caused wildfires that could threaten both private and public lands. Within the Project Area, stands of conifer species, primarily red pine plantations, are overcrowded and stagnate, and are areas where intense wildfires can become hard to control. Such fires threaten both private property as well as valuable stands of timber and important wildlife habitat on public lands. The extensive network of both public use and non-public use roads in the Project Area provide for activities such as hunting and camping that can increase opportunities for wildfires to start.

Additionally, stands that have not experienced fire in recent history have a higher occurrence of dead and down vegetation on the forest floor. This increased surface fuel loading, if a wildfire were to start or enter these areas, could exhibit wildfires with high intensity. These wildfires, therefore, would be more difficult to control and increase the potential for a fire to damage private property and threaten important forest resources.

Desired Condition: The red pine plantations of the Project Area are thinned to reduce canopy closure and allow for improved growing conditions, leading to healthier trees and reducing the amount of tree mortality due to overcrowding, as well as reducing the potential fire spread through the canopies. In some of these red pine stands, as well as other forested stands, prescribed fire would be used to reduce existing surface fuel loading.

Areas converted to savanna, and existing openings, including grass openings and prairies, would be treated with fire, where appropriate. By maintaining a matrix of more open areas, these stands would act as non-linear fuelbreaks in an otherwise largely forested landscape. When high-intensity wildfires burning in stands with large amounts of surface fuels burn into these fuelbreaks (open areas), the fire intensity would decrease, making control efforts easier.

Need: The large areas of pine dominated stands pose a potential threat to the HMNF"s resources and to private landowners. Thinning these stands to decrease their potential for high-intensity wildfires is needed. The addition of more open areas, such as prairie and savanna, would further

act to reduce overall fire intensity and increase the ability to control fire in the case of wildfire in the Project Area.

Provide recreational opportunities while protecting the unique ecosystem characteristics of the Project Area

Existing Condition: The recreational opportunities available in the Project Area include fishing, hunting, wildlife watching, biking, horseback riding, ORV riding on County roads, hiking, camping, and snowmobiling on designated trails/roads. The North Country National Scenic Trail (NCT) traverses the Project Area and provides hikers with an opportunity to view unique landscapes. Currently, there is widespread use of NFS lands and utility corridors in the Project Area for unapproved recreational activities, the primary one being ORV use. ORV use has resulted in resource damage and has led to the degradation of rare habitat types, such as prairies and grasslands, and potentially the endangered plant and animal species that rely on these habitats.

Desired Condition: The Project Area continues to provide for a wide range of outdoor recreational activities. The amount of habitat for wildlife species, both common and rare, is enhanced by the various vegetation management activities that are to take place and provides for additional recreational opportunities in the areas of wildlife viewing, berry gathering, and hunting. Hiking, biking, and horseback riding opportunities are enhanced by road system activities. Motorized access and recreation continues to occur in the Project Area on an improved road system, while unauthorized motorized use is minimized. The increase in the amount of rare ecosystem habitat type's results in the ability to view native ecosystems and the plant and animal species associated with them. The NCT continues to allow people to view the unique features of the Project Area, and the creation of savanna and prairie habitats will allow for additional viewing opportunities along the trail. At the same time, the NCT will be protected from impacts due to management activities through the use of buffers along the trail and other mitigation measures to protect the trail from physical damage.

Fishing opportunities would be increased in Bigelow Creek by improving instream habitat and providing additional shade trees in the riparian area, which would enhance stream habitat qualities beneficial to fish species. Upgrades of road-stream crossings would remove barriers to fish passage opening up more habitat for a variety of fish species and other aquatic organisms.

Need: There is a need to repair and restore areas that are experiencing impacts from unauthorized recreational use. In addition, there is a desire to maintain the diversity of recreational opportunities that now exist in the area, including hunting, fishing, hiking, camping, horseback riding, gathering forest products, and driving for pleasure.

Proposed Action

The Bigelow-Newaygo Project's Proposed Action was described in the March 20, 2014, scoping letter. The range of activities has remained the same as those described in the scoping letter, but the acreages or treatments have changed in some instances due to updated information or in response to comments received during scoping. It was also decided to not include the development of three water holes for wildlife as it was found that water was not a limiting resource in the area for wildlife.

In addition, while the Bigelow-Newaygo Project's analysis was in the process of being written for this document, the Forest Service received a grant in Fiscal Year 15 to address illegal ORV damage identified in this EA; in particular was resource damage in stands 5, 7 and 8 in Compartment 513 and therefore the Forest Service chose to pull this aspect of the proposed action out of this EA and instead address it separately under a Categorical Exclusion so the project work could be initiated in Fiscal Year 15. The Basswood Decision Memo was signed on June 12, 2015 after appropriate public scoping. Stand 7 will continue to have opening restoration activities performed, while Stand 8 will continue to be restored to a savanna as described under the EA. Stand 5 will no longer be treated under the Bigelow-Newaygo EA. The reduction in damage restoration acres will be reflected in this EA and the Final Decision Notice and Finding of No Significant Impact.

The modified proposed activities are described below:

Project Objective - Restore and maintain savannas, prairies, dry grasslands, and mesic grasslands where they were known to previously occur for habitat diversity and to meet species viability needs

Vegetative treatments (all acres are approximate) would be utilized to expand the grassland, prairie and savanna habitats in the Project Area. Treatments include: 102 acres of forested stands would be converted to openings by removing the woody vegetation; 345 acres of existing openings would be restored and/or maintained; 485 acres of oak and oak-dominated stands and red pine (314 acres and 171 acres, respectively) would be converted to savanna; and broadcast burning would occur on approximately 696 acres to facilitate conversion and maintenance of these vegetation types.

The Forest Service will monitor the implementation of these treatment activities to ensure management objectives are met, or make subsequent changes in treatment activities to ensure objectives are achieved.

To achieve the goal of restoring and maintaining savannas, prairies, and grasslands for habitat diversity and species viability needs, management tools need to be adaptive. Treatment options need to be flexible so they can be tailored to a specific site. Therefore, the following activities may be used, and the number of acres given is the maximum that could be treated by activity type, although not all treatments would be used on all acres. Treatments may include the following: 932 acres of mechanical woody vegetation removal; 932 acres of manual woody vegetation removal; 100 acres of woody vegetation herbicide treatment; 932 acres of additional broadcast burning; 242 acres of native plant seeding; and 100 acres of site preparation. The maximum number of acres treated, 932, is the total of treatments proposed for opening creation, opening restoration, and savanna creation meaning that multiple treatment types may occur on the same acreage not to exceed 932 acres. Finally, steps may be taken on a maximum of 932 acres to protect the restored or created habitat, including, but not limited to, temporary closure orders, installation of physical barriers, and/or other activities required to limit the potential for resource damage.

Road system activities would take place to limit motorized access to sensitive habitats and to reduce the amount of unclassified roads, roads which are not open to public use, in the Project Area. Other road system activities would take place to improve access to stands for treatment activities and for hauling of timber. These road system activities include up to 0.6 miles of new Forest roads open to public use, reconstruction of 4.9 miles of Forest and County roads open to

public use, and the closure of 3.9 miles of existing Forest roads that are currently open to public use. In addition, unclassified Forest roads in the Project Area would be closed.

Finally, to further enhance the quality of existing habitat and to allow for management activities to be successful, invasive plants, and stands with damage from unauthorized ORV use and/or dumping would be treated. Approximately 108 acres of NNIP herbicide treatment would be conducted throughout the Project Area. This would reduce harmful infestations of undesirable plant species that would compete with the native plant species that are present and are important to the successful establishment of prairie and savanna habitats. Activities, such as road closures, would take place mitigating the effects of resource damage found on 147 acres in the Project Area.

Project Objective - Wildlife and fisheries habitat, and plant communities will be managed to maintain viable populations of existing native and desired non-native species

The same vegetative treatments, road system activities, NNIP treatments, and prescribed burning proposed for the restoration and maintenance of prairie and savanna habitats (Purpose and Need #1), will also address the goal of managing wildlife, plant, and fisheries habitat to maintain viable populations of native and desired non-native species.

In addition, approximately 28 instream large woody debris structures would be reconstructed or replaced in Bigelow Creek and approximately 17 acres of riparian tree planting would occur in the riparian corridor. Throughout the Project Area, up to 9 road-stream crossings would be rebuilt to improve passage for aquatic species and address run-off and sedimentation issues at these crossings.

Project Objective - Reduce life-threatening and property damaging wildfire potential

To reduce canopy closure in pine plantations, thereby reducing the potential for a high-intensity crown fire and enhancing tree vigor and health, approximately 1,412 acres of predominantly red pine stands would be thinned. In addition, 45 acres of red pine stands would be treated with an overstory removal harvest. As previously mentioned, broadcast burning of 696 acres would be used to enhance habitat quality and reduce surface fuels loading on these sites. Of these 696 acres, 447 are in pine-dominated stands, while the remaining 249 acres are in hardwood-dominated stands or existing openings.

The additional approximately 932 acres of broadcast burning (the maximum additional acres allowed) would also reduce fuel loading in the stands to be managed as well as maintain these acres in a more open state with reduced surface fuel loading, as needed to meet objectives.

The management of the road system as described under the Purpose and Need would also reduce the potential for damaging wildfires by minimizing opportunities for wildfires to start due to accidental, or other human-caused ignitions.

Finally, it is worth noting that the proposed action calls for a minimum of approximately 696 acres of broadcast burning to take place within the Project Area but there is the potential for an additional 932 acres to take place depending on management needs. All prescribed burning would be conducted when conditions are appropriate for using fire as a management tool. By

using prescribed burning, the potential for future wildfires is reduced, and therefore the potential for damage to public and private property is reduced.

Project Objective - Provide recreational opportunities while protecting the unique ecosystem characteristics of the Project Area

The treatments described previously which would enhance wildlife and plant habitat as well as rare ecosystems will also provide enhanced recreational opportunities. Wildlife viewing and hunting would be enhanced by those activities previously described such as opening creation and restoration, and savanna creation.

Road system activities would limit motorized access in some areas of the Project Area, while at the same time providing opportunities for non-motorized activities such as hiking, biking, and horseback riding. However, road reconstruction and new road construction would lead to improved access for motorized recreation in other areas of the Project Area.

The treatments previously described for fish habitat enhancement would provide for improved fishing opportunities in Bigelow Creek.

The treatment of NNIP in the Project Area, and the restoration of areas impacted by resource damage as a result of off-road motorized activity, would improve the area by eliminating areas that are visibly unappealing.

Scoping and Public Involvement

The Forest Service uses public involvement and an IDT of resource specialists to determine issues of concern and develop possible solutions. Scoping is a process for gathering comments about a site-specific proposed Federal action to determine the scope of issues to be addressed and for identifying unresolved issues related to the proposed action (40 CFR 1501.7). Opportunities for comments enable concerned citizens, resource specialists from other agencies, Tribes, and local governments to express their ideas and views.

Public involvement for the Project included listing the Proposed Action in the HMNF's Schedule of Proposed Actions; a direct mailing on March 20, 2014, to approximately 325 individuals, organizations, Tribal governments, and adjacent landowners; and, a listing on the HMNF's website. During the scoping period, 33 responses were received.

Relevant Issues

A relevant issue results from discussion, debate, or disagreement regarding the effects of the proposed activities. They are developed from comments received from within and outside the Forest Service. In order to provide a concise analysis, the agency distinguishes between an issue that is used in the analysis for formulating alternatives, developing mitigation, and tracking effects. An issue that drives the development of alternatives is identified as a relevant issue. Other issues and management concerns are addressed in the Environmental Effects section in Chapter 3 of the EA, but are not used to develop alternatives. The relevant issues identified for this project are:

Conversion of red pine stands to prairie

Issue: There were concerns that converting forested stands to non-forested stands would affect the aesthetics for adjacent landowners, contribute to increased unauthorized use of the Project Area by encouraging users causing resource damage in current openings to expand their activities to newly opened areas, and converting productive forested stands to openings.

In response to this issue, portions of red pine stands that were to be converted to prairie (this does not include portions of red pine stands that would be converted to upland openings) would be thinned only, and therefore no expansion of current prairie areas would take place. Overall, this reduced the number of opening creation acres proposed.

Measurement: Acres of red pine converted to prairie; acres of red pine thinning

Savanna restoration activities in areas with difficult access and high boundary line costs

Issue: There were concerns that lack of access and the high cost of surveying boundary lines, would make the conversion of some stands economically non-viable. Other comments were received that mirrored those mentioned above for opening creation, namely that additional open land would increase the possibility of continued, and potentially increased, unauthorized use of the Project Area by those using primarily ORVs.

In response to this issue, several isolated stands that were originally slated for savanna restoration were dropped from management consideration. Overall, this reduced the number of savanna restoration acres proposed.

Measurement: Acres of savanna restoration activities.

Road closures

Issue: Road closures proposed throughout the Project Area were questioned as to the resource concerns addressed by the closures. In the road system analysis conducted for the Project, roads were identified for closure if they were duplicating access that another road was providing or the road usage was causing resource damage. Some commenters questioned the need to close roads at all.

In response to this issue, construction of new roads in the southernmost portion of the project Area was dropped in all alternatives. In addition, if a road that was proposed to be closed due to resource damage, that road would continue to be designated for closure. However, those roads that were proposed to be closed to reduce duplication of access would remain open.

Measurement: Miles of road closures

Other Issues and Management Concerns

The following issues and resources have been discussed and/or evaluated in recent similar projects. Some may be determined to be minor because they would not be affected by the project design. Only issues and resources that would be impacted by an action alternative or vary greatly between alternatives would be used to evaluate the alternatives for this project.

Management Indicator Species and Wildlife

The effects of the proposed activities on Management Indicator Species and wildlife will be evaluated as part of the analysis. Measures to minimize impacts to Management Indicator Species and Wildlife resources will be incorporated into the project.

Vegetation Resources

The current vegetative resources and the expected changes as a result of implementing the proposed vegetative treatments, including the timber harvest treatments and opening creation, will be evaluated as part of the analysis. Measures to minimize impacts to vegetation resources will be incorporated into the project.

Fuels

The effects of the proposed activities on the fuel loading, as well as the potential for a high intensity wildfire to occur in the area, and its effects on the forest resources, as well as its effects on private property will be evaluated as part of the analysis.

Soil Productivity

Potential impacts to soil resources will be evaluated as part of the analysis. Measures to minimize impacts to soil resources will be incorporated into the project.

Air Quality

Potential impacts to air resources will be evaluated as part of the analysis. Measures to minimize impacts to air resources will be incorporated into the project.

Water Quality and Fisheries

Potential impacts to water resources and in particular impacts to the watersheds that comprise the Project Area will be evaluated as part of the analysis. In addition, the potential impacts to the fisheries will also be evaluated. Measures to minimize the impacts to the water resources and the fisheries will be incorporated into the project.

Threatened, Endangered, and Sensitive Species

Threatened, endangered, and sensitive plant and animal species have been identified in the Project Area. A Biological Evaluation will be completed as part of the analysis to determine the effects on threatened and sensitive plant and animal species. Mitigation measures and management for threatened and sensitive species will be incorporated into the design of the project. The analysis will address how the proposed activities may adversely affect or protect endangered, threatened, and sensitive plant and animal species and maintain and/or improve habitat conditions.

Non-Native Invasive Plant Species

This analysis will address the measures taken for invasive plant control of species already present in the Project Area and evaluate measures to reduce additional spread or introduction of invasive plants in areas that are to be managed.

Heritage Resources

Heritage resources have been identified in the Project Area. Recommended protection measures for these resources will be incorporated into the design of the project.

Economics

The EA will address the effects of the proposed treatments and actions on social and economic concerns and evaluate the cost-revenue of the alternatives.

Recreation and Visual Quality

The analysis will evaluate how the proposed activities affect the visual quality and recreational use in the Project Area. Measures to minimize the impacts to the recreation resources will be incorporated into the project.

Transportation

The analysis will address the effects of the management activities on the transportation system.

Civil Rights and Environmental Justice

The analysis will address the civil rights and environmental justice impacts associated with implementation of the Project.

Irreversible and Irretrievable Commitment of Resources

Potential irreversible and irretrievable impacts are disclosed with the implementation of the alternatives.

Decision to be Made

Based on the analysis of the environmental effects in the EA, the responsible official (the District Ranger of the BWC Ranger District), must decide whether or not to implement the proposed management activities, including vegetation management, wildlife habitat improvement, and transportation system management, and decide on the amount, type, and location of these activities.

Implementation

All activities proposed in the Selected Alternative would be implemented within approximately 10 years of the signing of the Decision Notice for this project. The decade-long timeframe is the amount of time during which the activities would likely start and finish. It can take 3-5 years to conduct a timber harvest, after the preparation and administration of the sale has been completed. There are additional activities, such as site preparation and planting, that would follow the harvest in order to adequately regenerate the stands. The entire process would likely take place within this 10-year timeframe, although unforeseen circumstances could alter timelines.

Availability of the Planning Record

An important consideration in preparation of this EA has been the reduction of paperwork as specified in 40 CFR 1500.4. In general, the objective is to furnish enough site-specific information to demonstrate a reasoned consideration of the environmental impacts of the alternatives and how these impacts can be mitigated. The planning record contains detailed information used in creating the EA. This and other reference documents are available at the BWC Ranger District Office in Baldwin, Michigan.

CHAPTER 2
ALTERNATIVES

Introduction

This chapter describes the alternatives for restoring and maintaining savannas, prairies, dry grasslands, mesic grasslands where they were known to previously occur for habitat diversity and to meet species viability needs; managing wildlife and fisheries habitat, and plant communities, to maintain viable populations of existing native and desired non-native species; reducing life-threatening and property damaging wildfire potential; and, providing recreational opportunities while protecting the unique ecosystem characteristics of the Bigelow-Newaygo Project Area. The Modified Proposed Action (Alternative 2), Alternative 3 (the Action Alternative), and the No Action Alternative (Alternative 1) for this project are described in this chapter. Table 2-1 displays the comparison of alternatives by issue and project objectives. The Bigelow-Newaygo Project vicinity is shown on Map 1 at the end of this chapter.

Alternative Development Process

To prepare this analysis, a group of resource specialists, known as an interdisciplinary team (IDT), met and discussed how best to accomplish the objectives described in the Purpose and Need section of Chapter 1. The IDT members and resource specialists consulted for this project are listed in Chapter 4. The IDT identifies issues raised in the public scoping process and from internal comments. In consideration of these issues, the IDT designs alternatives that also address the project's Purpose and Need. The National Environmental Policy Act regulations mandate consideration of all reasonable alternatives for a proposed action, including identification and discussion of alternatives eliminated from detailed study.

To develop alternatives, the IDT first reviewed all the comments and concerns expressed by the public and internal sources during the scoping process. These comments and concerns were then consolidated into a relevant issue. Once a relevant issue had been identified, the IDT developed strategies that can be used to resolve the issue while responding to the Purpose and Need objectives. The IDT also identified indicators or measurements used to compare how each alternative responds to the issues for which it was developed.

The Proposed Action and the Action Alternative were designed to meet the objectives and to address and resolve issues of public concern. The Action Alternative represents a site-specific mix of proposals that responds to these issues. From this range of alternatives, the Baldwin-White Cloud District Ranger has a basis for judging the trade-offs between implementing each alternative, including the No Action Alternative.

Alternatives Considered in Detail

This assessment will evaluate the No Action Alternative (Alternative 1), the Modified Proposed Action (Alternative 2), and the Action Alternative (Alternatives 3), which are described below. Both of the action alternatives are consistent with the standards and guidelines of the Forest Plan. Table 2-1: *Treatment Activities by Alternative* displays a summary comparison of alternatives by activity.

Alternative 1
No Action

Alternative 1 is the No Action Alternative. Under Alternative 1, none of the proposed vegetative treatments or other management activities would occur in the Project Area on National Forest System (NFS) lands. Some activities, such as resource protection, would continue within the Project Area. Selection of Alternative 1 does not preclude future analysis or implementation of on-going management proposals within the Project Area.

Alternative 1 Summary:

- Under Alternative 1, none of the proposed vegetative treatments or other management activities would occur in the Project Area on NFS lands.
- Provides a baseline against which to describe the environmental and social effects of the action alternatives.
- Responds to those who want no management activities to take place in the Project Area, such as savanna restoration and other harvesting activities.
- Does not achieve the project's Purpose and Need objectives.
- Does not achieve the Forest Plan's desired condition for vegetative management, wildlife habitat improvements, and transportation system management.

Alternative 2
Proposed Action

Alternative 2 is the Modified Proposed Action that was described during scoping with minor changes to the original proposal. These changes are the result of a stand being dropped and changes in management objectives following further discussion within the IDT. In addition, while the Bigelow-Newaygo Project's analysis was in the process of being written for this document, the Forest Service received a grant in Fiscal Year 15 to address illegal ORV damage identified in this EA; in particular was resource damage in stands 5, 7 and 8 in Compartment 513 and therefore the Forest Service chose to pull this aspect of the proposed action out of this EA and instead address it separately under the Basswood Categorical Exclusion. Therefore, stand 7 will continue to have opening restoration activities performed, while Stand 8 will continue to be restored to a savanna, while stand 5 will no longer be treated under the Bigelow-Newaygo EA. The reduction in damage restoration acres is reflected in the below table.

This alternative would implement the most vegetative treatments and the most wildlife habitat improvement activities in the Project Area. Also, the greatest amount of activity on the road system would take place.

Alternative 2 Summary:

- Conducts vegetative, wildlife, fuels, road system and miscellaneous activities that include approximately:
  - 1,412 acres of pine thinning
  - 45 acres of conifer overstory removal harvesting

102 acres of opening creation
345 acres of opening restoration/maintenance
485 acres of savanna restoration
696 acres of broadcast burning
up to 932 acres of mechanical or manual woody vegetation removal
up to 100 acres woody vegetation herbicide treatment

up to 932 acres prescribed burning
up to 242 acres of native plant seeding

up to 100 acres of site preparation
up to 932 acres of habitat protection measures
0.6 miles of road construction (Forest Service Level 2)
2.4 miles of road reconstruction (Forest Service Level 2)
2.5 miles of road reconstruction (County)
3.9 miles of road closure (Forest Service Level 2)
up to 28 instream structures to be maintained in Bigelow Creek
17 acres of riparian planting
9 road-stream crossing improvements
147 acres of repairing resource damage
108 acres of non-native invasive plants (NNIP) herbicide treatment

- Achieves the project's Purpose and Need objectives.
- Achieves the Forest Plan's desired condition for vegetation management, wildlife habitat improvements, and road system activities.
- The 102 acres of opening creation would be remove land suitable for timber production (LSC 500), to an LSC 200, a non-forested land classification.

Alternative 3
Action Developed in Response to Issues

Alternative 3 was developed in response to comments received during the scoping period and from IDT members. It responds to comments regarding the amount and locations of savanna restoration and opening creation activities. As a result the amount of savanna restoration and opening creation was reduced. Also, comments were received that called for fewer road closures in the Project Area. As a result those roads that were not causing resource damage were dropped from the Alternative. In addition, as mentioned in the description for Alternative 2, several stands that were proposed for resource damage mitigation were identified for expedited treatment. These stands were treated separately under the Basswood ORV Damage Restoration Categorical Exclusion decision document.

Alternative 3 Summary:

- Conducts vegetative, wildlife, fuels, road system and miscellaneous activities that include approximately:
  1,457 acres of pine thinning
  45 acres of conifer overstory removal harvesting
  58 acres of opening creation
  343 acres of opening restoration/maintenance

329 acres of savanna restoration
746 acres of broadcast burning
up to 700 acres of mechanical or manual woody vegetation removal
up to 100 acres woody vegetation herbicide treatment
up to 700 acres prescribed burning
up to 152 acres of native plant seeding
up to 100 acres of site preparation
up to 700 acres of habitat protection measures
0.6 miles of road construction (Forest Service Level 2)
2.4 miles of road reconstruction (Forest Service Level 2)
2.5 miles of road reconstruction (County)
2.8 miles of road closure (Forest Service Level 2)
up to 28 instream structures to be maintained in Bigelow Creek
17 acres of riparian planting
9 road-stream crossing improvements
147 acres of repairing resource damage
108 acres of NNIP herbicide treatment

- Achieves the project's Purpose and Need objectives.
- Achieves the Forest Plan's desired condition for vegetation management, wildlife habitat improvements, and road system activities.
- The 58 acres of opening creation would be remove land suitable for timber production (LSC 500), to an LSC 200, a non-forested land classification.

Conservation Measures

Conservation measures are designed to counteract environmental impacts or to make impacts less severe. These may include: avoiding an impact by not taking a certain action or part of an action; minimizing an impact by limiting the degree or magnitude of an action and its implementation; rectifying the impact by repairing, rehabilitating, or restoring the affected environment; reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; or compensating for the impact by replacing or providing substitute resources or environments. Some conservation measures may apply only to a specific treatment unit or units.

All relevant conservation measures, both site-specific and those common to all alternatives, can be found in Appendix A.

Monitoring

Monitoring would be conducted to determine if resource management objectives for the Project Area have been met. Monitoring results would be used to verify the effectiveness of selected mitigating and protective measures in a timely manner. This process ensures that project elements are implemented as designed and that standards and guidelines are implemented to protect soil, water, and other resources. The following monitoring would be performed for all action alternatives:

Implementation Monitoring

Mitigation Measure Implementation

Objective: Ensure mitigation measures for each treatment unit are being implemented.
Desired Results: Mitigation measures are effective in addressing resource issues.
Methods: All treatment units would be visited by district personnel. Reviews would be documented in inspection reports regarding contract compliance.
Responsibility: District assistant rangers for timber, recreation, and wildlife.

Contract Administration

Objective: Ensure that mitigation measures are implemented for treatment units with commercial harvesting.
Desired Results: All contract requirements are met.
Methods: All treatment units would be visited by the timber sale administrator.
Responsibility: District timber sales administrator.

Karner Blue Butterfly

Objective: Ensure that stands occupied by active populations of KBB are protected.
Desired Result: Areas that are protected do not experience resource degradation or the potential loss of individual or entire populations of the KBB.
Methods: Ocular inspection within the first two years after the treatment of a unit.
Responsibility: District wildlife biologist

Invasive Plants

Objective: Ensure that the spread of invasive plants is minimized.
Desired Result: No spread of invasive plants due to treatments would occur.
Methods: Ocular inspection within the first two years after the treatment of a unit.
Responsibility: District botanist.

Research Natural Area

Objective: Ensure that the treatment activities taking place in the Research Natural Area (RNA) meet the requirements as stated in the consultation document with the Northern Reseacrch Station.
Desired Result: No negative impacts to the RNA as proscribed on the consultation document.
Methods: Silviculturist will be on site during any treatment activity.
Responsibility: District silviculturist.

Effectiveness Monitoring

Prairie and Savanna Restoration

Objective: Ensure that management activities are effective in restoring prairie and savanna habitat types.
Desired Result: Functioning prairie and savanna ecosystems.
Methods: Vegetattion stocking surveys within the first five years after the treatment of a unit.
Responsibility: District botanist and district wildlife biologist.

Reforestation

Objective: Ensure that reforestation occurs within five years of treatment.
Desired Result: Adequately reforested stands.
Methods: Stocking surveys within the first five years after the treatment of a unit.
Responsibility: District silviculturist.

Forest Plan Monitoring

The National Forest Management Act requires that National Forests monitor and evaluate their forest plans. Forest plan monitoring is conducted over the entire Forest on a periodic basis. Samples for Forest Plan monitoring may or may not be taken in the Project Area; however, monitoring results are designed to answer questions regarding the implementation and effectiveness of mitigation. Forest Plan monitoring results can be found in the 2010/2011 Monitoring and Midterm Evaluation Report found on the HMNF's website.

Alternative Considered but Eliminated from Detailed Study

The IDT considered an additional alternative during the analysis before a reasonable set of alternatives was considered for detailed study. The alternative that was eliminated from detailed study is described as follows:

Developing additional trails within the Project Area - Comments were received expressing a desire to see motorized and horse trails designated in the Project Area. Part of the Purpose and Need for the Bigelow-Newaygo project is to provide recreational opportunities while protecting the unique ecosystem characteristics of the Project Area; therefore, the designation of additional recreation trails was considered.

This alternative was eliminated from detailed study because of the limitations on developing contiguous trail systems created by the fragmented ownership. Public land is scattered with some parcels as small as 10 acres. Although opportunities to develop trail systems in the Project Area are limited, there are currently options available to those wanting to ride off-road vehicles (ORV) and horses. The majority of Newaygo County roads are open to ORVs. Additionally, the M-20 Motorsport Trail and the Trail 3 Snowmobile Trail are located just north of the Project Area. A trail for horseback riding is located in the Coolbaugh Natural Area and riding is allowed on County and Forest Service roads as well as the general forest area. The only areas not open to horseback riding in the Project Area are the North Country National Scenic Trail and the Newaygo Prairies RNA.

Treatment Activities by Alternative
Table 2-1

Relevant Issue	Measurement[1]	Alt. 1	Alt. 2	Alt. 3
Conversion of red pine stands to prairie	-acres of red pine converted to prairie -acres or red pine thinning	0 0	95 1,412	37 1,457
Savanna restoration activities in areas with access limitations and high boundary line costs	-acres of savanna restoration	0	485	329
Road closures	-miles or road closures	0	3.9	2.8
Project Objectives and Proposed Actions				
Restore and maintain savannas, prairies, dry grasslands, mesic grasslands where they were known to previously occur for habitat diversity and to meet species viability needs				
Opening creation	acres	0	102	58
Opening restoration/maintenance	acres	0	345	343
Savanna restoration	acres	0	485	329
Broadcast burning	acres	0	696	746
Mechanical or manual woody vegetation removal	acres	0	up to 932	up to 700
Woody vegetation herbicide treatment	acres	0	up to 100	up to 100
Prescribed burning	acres	0	up to 932	up to 700
Native plant seeding	acres	0	up to 242	up to 152
Site preparation	acres	0	up to 100	up to 100
Habitat protection measures	acres	0	up to 932	up to 700
Road construction/redesignation - L1 to L2[2]	miles	0	0.6	0.6
Reconstruction - L2 forest roads/county	miles	0	4.9	4.9
Road closure/redesignation - L2 to L1	miles	0	3.9	2.8
NNIS herbicide treatment	acres	0	108	108
Repair resource damage	acres	0	147	147
Wildlife and fisheries habitat, and plant communities, will be managed to maintain viable populations of existing native and desired non-native species				
Opening creation*	acres	0	102	58
Opening restoration/maintenance*	acres	0	345	343
Savanna restoration*	acres	0	485	329
Broadcast burning*	acres	0	696	746
Mechanical woody vegetation removal*	acres	0	up to 932	up to 700
Manual woody vegetation removal*	acres	0	up to 932	up to 700
Woody vegetation herbicide treatment*	acres	0	up to 100	up to 100

Prescribed burning*	acres	0	up to 932	up to 700
Native plant seeding*	acres	0	up to 242	up to 152
Site preparation*	acres	0	up to 100	up to 100
Habitat protection measures*	acres	0	up to 932	up to 700
Road construction/redesignation - L1 to L2*	miles	0	0.6	0.6
Reconstruction - L2 forest roads/county*	miles	0	4.9	4.9
Road closure/redesignation - L2 to L1*	miles	0	3.9	2.8
NNIS herbicide treatment*	acres	0	108	108
Repair resource damage*	acres	0	147	147
Maintenance of Bigelow Creek instream structures	each	0	up to 28	up to 28
Riparian planting	acres	0	17	17
Road/stream crossing improvements	each	0	9	9
Reduce life-threatening and property damaging wildfire potential				
Commercial thin	acres	0	1,412	1,457
Overstory removal harvest	acres	0	45	45
Broadcast burning*	acres	0	696	746
Prescribed burning*	acres	0	up to 932	up to 700
Road construction/redesignation - L1 to L2*	miles	0	0.6	0.6
Reconstruction - L2 forest roads/county*	miles	0	4.9	4.9
Road closure/redesignation - L2 to L1*	miles	0	3.9	2.8
Provide recreational opportunities while protecting the unique ecosystem characteristics of the Project Area				
Opening creation*	acres	0	102	58
Opening restoration/maintenance*	acres	0	345	343
Savanna restoration*	acres	0	485	329
Road construction/redesignation - L1 to L2*	miles	0	0.6	0.6
Reconstruction - L2 forest roads/county*	miles	0	4.9	4.9
Road closure/redesignation - L2 to L1*	miles	0	3.9	2.8
Maintenance of Bigelow Creek instream structures*	each	0	up to 28	up to 28
Riparian planting*	acres	0	17	17
NNIS herbicide treatment*	acres	0	108	108
Repair resource damage*	acres	0	147	147

[1]*All acres and miles are approximate.*
[2]*Level 1 (L1) roads are permanent roads that are used only for Forest Service administrative purposes and Level 2 (L2) roads are permanent roads open to all.*

*These proposed actions meet multiple project objectives and appear on the above table multiple times.

CHAPTER 3
AFFECTED ENVIRONMENT AND ENVIRONMENTAL EFFECTS

Introduction

This chapter presents information on the existing conditions in the Bigelow-Newaygo Project Area (henceforth referred to as the Project Area) and an analysis of the effects of the No Action Alternative (Alternative 1), the Proposed Action (Alternative 2), and one Action Alternative (Alternative 3) on the environment. The affected environment for this project is the Project Area within the Huron-Manistee National Forests (HMNF). Resource-specific information, existing condition, and environmental effects are discussed together under each issue. This chapter presents a summary of the analysis and the data utilized in completing the analysis. The information used to prepare this analysis is in the Project Planning Record and is available for review at the Baldwin-White Cloud (BWC) Ranger District.

Area of Analysis

The area of analysis for this project includes all the compartments that make up the Project Area including private and State lands. In the discussion of the resource areas and their effects that follows, some resources require a larger area of analysis. An example would be air quality issues that could impact areas outside the Project Area. In those cases, the area of analysis is discussed or defined under the relevant issue or other resource areas.

Vegetation Resources

Area of Analysis

The analysis area for direct and indirect effects on vegetation resources includes National Forest System (NFS) lands within the boundaries of Forest Service management units designated as BWC District compartments 513, 517, 519, 520, 521, 522, 573, 576, 578, 582, and 586 located in Mecosta, Montcalm and Newaygo Counties, MI. The analysis area for cumulative effects of vegetation composition includes NFS lands, and other public and private lands, within the HMNF. This large area allows for a comparison to be made on current and future vegetative patterns on similar forest ecosystems, in response to market and non-market forces.

Historical Perspective

Historically, the area was impacted in the late 1800s and early 1900s by logging practices, conversion of forests to agriculture and range lands, and periodic fire events. Fire suppression has occurred throughout the Project Area in the last 100 years. Pre-settlement vegetation in the Project Area was generally dominated by forests of the white-red pine, hemlock-white pine, white pine-white oak, mixed hardwood and conifer swamp, oak-pine barrens, mixed oak savanna, beech-sugar maple, pine barrens, and grasslands (Comer and Albert 1998). Through natural

regeneration, fire suppression, and reforestation, these lands have generally been reforested to red and white pine, mixed oaks, aspen, although areas of degraded grassland and savanna exist. Typically, areas affected by past agricultural disturbances have been planted to pine plantations; other areas have naturally regenerated to oaks, aspen, or other hardwood species. Fire suppression and woody encroachment have contributed to the population decline and loss of plant species inhabiting open areas. Native and non-native insects (especially emerald ash borer), diseases (especially oak wilt, and also beech bark disease), and plants (especially autumn olive and honeysuckle spp.) have also affected the vegetative resources of the Project Area.

Climate Change

Agencies apply the rule of reason to ensure that their discussion pertains to the issues that deserve study and deemphasizes issues that are less useful to the decision regarding the proposal, its alternatives, and mitigation options (40 CFR 1500.4(f), (g), 1501.7, 1508.25). In addressing greenhouse gas (GHG) emissions, consistent with this proposed guidance, CEQ expects agencies to ensure that such description is commensurate with the importance of the GHG emissions of the proposed action, avoiding useless bulk and boilerplate documentation, so that the NEPA document may concentrate attention on important issues (40 CFR 1502.5, 1502.24).

Because it is not possible to predict the actual effects of a particular project on global climate change or local climate, a baseline comparison of climate change cannot generally be made using the No Action Alternative and comparison of alternatives is generally not essential to a reasoned choice among them.

However it should be noted that Forests in the Eastern Region continue to be a net carbon sink. That is, they take up more carbon than they release. This is true of U.S. forests generally (USDA 2013a). Total forest ecosystem carbon stored in the Eastern Region slowly increased from 1990 to 2001, after which period the increase was more rapid…During this period the Huron-Manistee, Mark Twain, Ottawa, Shawnee, Hiawatha…generally increased in total forest ecosystem carbon…(USDA 2013a). The HMNF's timber harvest levels are expected to be similar to what they were during this time frame (which ranged from a low of approximately 26,784 MBF in 2003 to a high of 57,176 MBF in 2010), and the Forests position as carbon sink would be expected to continue. Further, much of the wood harvested from the Forests still stores carbon after it is cut. Using the IPPC/Environmental Protection Agency (EPA) production accounting approach the eastern region had 11,958,121 MgC total carbon stored in harvested wood products in 2000. In 2005 the region had 12,358,148 MgC and in 2010 the region had 12,552,233 MgC (Loeffler et al 2014).

We believe that the scope of our analysis is, in fact, commensurate with the effects of our proposal. The proposal is for sustainable forestry, which is considered to contribute to carbon sequestration.

Currently, forest management in the U.S. results in net sequestration. The likelihood that alternatives for a particular project would make a measurable difference in this pattern (which includes past, similar projects) is limited.

"*Land use, land-use change, and forestry activities in 2011 resulted in a net C sequestration of 905.0 Tg CO_2 Eq...this represents an offset of approximately 13.5 percent of total U.S. CO_2 emissions*" (US EPA 2014).

Effects of Climate Change on Forest Resources and Ecosystem Services

Modeled predictions of future climactic conditions vary widely depending on assumptions used and on future GHG emission scenarios. For example, "*Projected climate trends for the next 100 years using downscaled global climate model data indicted a potential increase in mean annual temperature of 1.3 to 7.1 ºF for the assessment area. Projections for precipitation indicate an increase in winter and spring precipitation, and summer and fall precipitation projections vary by scenario*" (Handler et al 2014). Such models are therefore insufficient (and not intended) for making detailed site specific land management decisions in the present day.

Because it is not possible to predict with real certainty what the change in precipitation or temperature throughout the year would be in the future for any given specific site, it is impossible to say with any certainty what additional stressors may affect species and habitats in the future. So a clear evaluation of the effects of an uncertain change in climate on the natural environment is not possible at this time. Accordingly, a relative comparison among alternatives for the most desirable outcome is not realistic.

However, "*Studies have consistently shown that more diverse systems are more resilient to disturbance, and low-diversity systems have fewer options to respond to change*" (Chapter 6, Handler et al 2014).

This project is in accordance with the 2012 Huron-Manistee National Forests Land and Resource Management Plan as Amended (hereafter referred to as the Forest Plan) and adheres to the Forest Service Silvicultural Handbook practices designed to produce wood products while sustaining and enhancing forest productivity and maintaining forest health. This project is designed to make the forest less susceptible to catastrophic losses from a severe wildfire or pest outbreaks and maintain a diversity of species types in the Project Area.

Forest Vegetation Age Classes, Composition, and Structure

The forest cover types and 10-year age classes present on NFS lands are found in Table 3-1 and Figure 3-1.

Composition

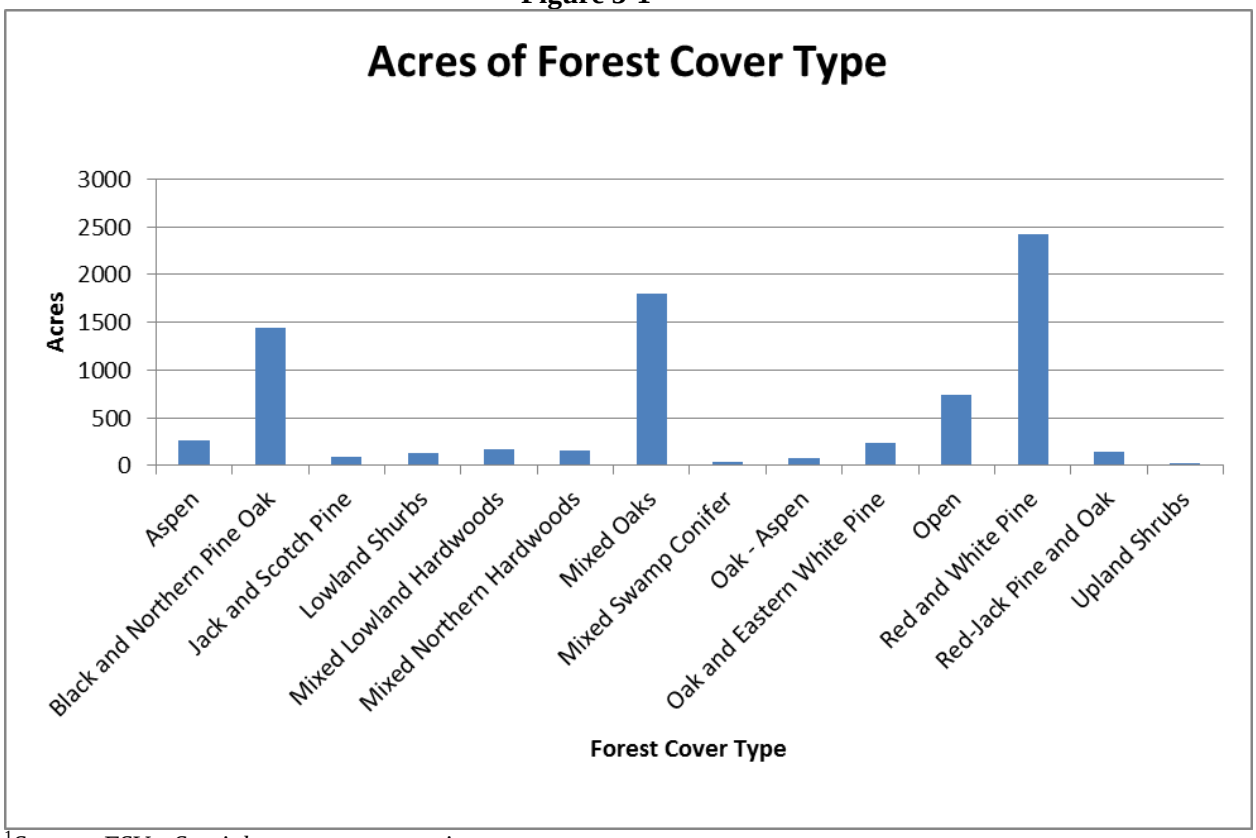
The Forest Plan provides composition objectives on Manistee National Forest (MNF) lands for the desired amount of each vegetation class. A vegetation class groups similar forest cover types using biological and ecological criteria. One of the criteria is site index, which measures the productivity of a particular site by relating the age and height of co-dominate trees and comparing that to compiled charts of the same species. In the Forest Plan, oak having a site index value ≤55 are low-site oaks, and oak having a value >55 are high-site oaks. Long-lived conifers are the red and white pine forest types, including oak mixes. Short-lived conifers include jack pine and jack pine-oak; the long and short lived designation for pines is based on the pine species longevity, not site index. Barrens and savanna vegetation types include current grassland and pine-oak areas that have few trees, i.e., never planted or very little woody encroachment, and located on dry, sandy soils. Opening vegetation types include other areas dominated by forbs and shrubs and a small component of trees, and include upland and wetland shrubs and all upland opening cover types.

Acres of Forest Type by Age Class in 2014[1] (NFS lands only)
Table 3-1

	Age Classes in Ten Year Groups													
Forest Cover Type	**None**	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**90-99**	**100-110**	**110-149+**	**Acres**
Jack/Scots pine	0	0	0	0	22	0	13	5	48	0	0	0	0	88
Red/white pine	0	0	37	17	0	162	478	563	954	81	0	41	95	2,428
Oak-eastern white pine	0	5	0	0	0	0	0	0	118	0	0	0	113	236
Oak-aspen	0	0	0	0	0	39	0	0	0	12	15	10	0	76
Red/jack pine-oak	0	0	0	4	0	0	0	45	93	0	0	0	0	142
Black/white oak	0	0	8	3	53	144	81	17	84	390	159	176	330	1,445
Mixed oak-red maple	0	0	0	0	0	0	39	14	355	406	337	210	375	1,736
Mixed northern hardwood	0	0	0	0	0	0	0	0	0	0	6	42	113	161
Mixed lowland hardwood/ conifer	0	0	0	0	0	0	0	0	0	103	107	0	0	210
Quaking-bigtooth aspen	0	0	50	0	0	32	0	0	123	58	0	0	0	263
Lowland shrub	126	0	0	0	0	0	0	0	0	0	0	0	0	126
Upland shrub	26	0	0	0	0	0	0	0	0	0	0	0	0	26
Upland opening	739	0	0	0	0	0	0	0	0	0	0	0	0	739
Total	**891**	**5**	**95**	**24**	**75**	**377**	**611**	**644**	**1,775**	**1,050**	**624**	**479**	**1,026**	**7,676**

[1]*Source: FSVegSpatial, acres are approximate.*

Acres of Forest Type by Age Class in 2014[1] (NFS lands only)
Figure 3-1



[1]*Source: FSVegSpatial, acres are approximate.*

These vegetation composition objectives are displayed in Table 3-2. These objectives serve as guidance for the desired vegetative composition on the MNF as a whole and are not intended to be mandatory on smaller sections of the Forest.

Based on these objectives, aspen/birch, northern hardwoods, lowland hardwoods and conifers and short-lived conifers are under-represented; long-lived conifers, high-site and low-site oaks (including jack pine-oak) are over represented. High-site oaks are over-represented because of the extensive moderate productivity soil areas, short-lived conifers are over represented because of plantations established in the past, and low-site oaks are over represented because of extensive low productivity soil areas. Northern hardwoods are not represented because soil productivity is generally too low to support this group; aspen-birch is under represented because high-site oaks and long-lived conifer plantations dominate soil types where this group could thrive; openings and barrens-savannas are poorly represented due to extensive conifer plantations and historic efforts to maintain upland openings on other landscapes.

Structure

The vertical structure of the existing vegetation is predominantly even-aged, with most trees having similar diameters, heights, and ages in any particular stand. This is particularly true in oak, aspen, and short-lived conifer forest cover types. Many long-lived conifer forest cover types are

Manistee National Forest Desired, Existing, and Project Area Vegetation Composition
Table 3-2

Vegetation Class	HMNF Forest Plan Desired in 2016	Manistee NF Existing[1]	Project Area Existing 2014
Aspen/birch	10-16%	13%	3.4%
Lowland hardwood and conifer	0-10%	9%	2.7%
Long-lived conifer	17-23%	21%	33.3%
High-site oak	15-21%	22%	27.3%
Opening	4-10%	7%	9.8%
Northern hardwood	8-14%	10%	2.0%
Short-lived conifer	2-8%	5%	1.1%
Low-site oak	13-19%	13%	18.9%
Barren and savanna	2-5%	0%	1.5%

[1]*As of February, 2014.*

also even-aged, but some locations have more than one age class of non-conifers present in the understory. Lowland hardwood and conifer forest cover types usually are uneven-aged, commonly having areas where two or more ages, classes, and species of trees dominate the forest canopy. The herbaceous layer in forested areas is strongly related to the Ecological Land Type Phase (ELTP) on which the forest occurs; low productivity soils feature Pennsylvania sedge, hairgrass, blueberry, and seedlings of oak and shrubs, while moderately productive soils feature maple-leaf viburnum, bracken fern, starflower, and various species of shrubs, hardwood and conifer seedlings (Cleland et al 1993). Forests located on high water table landscapes have a large number of herbaceous species, with wintergreen, violets, numerous ferns and shrubs, and hardwood and conifer seedlings present. Openings contain a wide variety of herbaceous species associated with both the ELTP and historic uses; sedge species and blueberry occur naturally, while warm or cool season grasses may have been cultured along with fruit bearing shrubs in upland locations; lowland opening are usually dominated by naturally established species, such as leather-leaf, fern, and sedge species.

The Newaygo Prairies Research Natural Area (RNA) was designated in 1993 and serves as a land base for the continuation of non-manipulative research on prairie habitats and low to moderately productive oak and pine ecosystems. No research or management activities have occurred on this

180 acre tract since designation, except to place barriers to restrict motor vehicle access. These ecosystems are fire dependent, and as a result of fire exclusion for many decades, the structure of the prairie in section 2 has been altered by encroaching pines, oaks, and non-native invasive plants (NNIP).

Insects and Disease

Oak decline (mortality brought on by drought stress, armillaria root rot, and two-lined chestnut borer, especially in trees older than age 100) is affecting some areas where soil productivity is low. The sirex woodwasp is a recently discovered invasive pest to Michigan. Although not currently located within the Project Area, the potential exists for it to become established in the future. The wasp larvae kill pine tree species by creating feeding tunnels under the bark. The most economical practice to reduce damage from this pest is to maintain healthy larger diameter stems, which can withstand more feeding tunnels than trees having a smaller diameter. Research shows that sirex woodwasp caused higher rates of mortality to smaller-diameter trees than larger-diameter trees and promoting the growth of healthy, vigorous trees reduces plantation-level mortality (Dodds et al 2007). Oak wilt is a fungal disease that is widespread in the Midwest. Control of oak wilt is expensive and involves severing root grafts between infected and healthy trees; prevention of oak wilt is possible by not wounding oak trees in the spring and early summer.

Beech bark disease is a combination of a non-native scale insect, the beech scale, and a *Nectria* fungus, and is present throughout Project Area. Beech bark disease has no practical control in a forest environment, and will persist and begin to cause mortality in the next decade. Emerald ash borer is also an introduced pest which has caused extensive mortality to ash species in the eastern U.S. Biological control of this species, using small wasp species, have been introduced onto the HMNF, but widespread mortality of ash trees will continue for the foreseeable future in the Project Area.

The growth of red pine improves with increasing live crown size, which is affected by stand density (Burns and Honkala 1990); periodic thinning of pine plantations reduces the stand density and also increases its resilience to climatic extremes (Magruder et al 2013). Red pine pocket mortality, commonly caused by armillaria root rot, is also frequent in plantations following thinning treatments; red and white pine mortality is also caused by the *Heterobasidion annosum* root rot. The non-native invasive insect, the sirex woodwasp, is attracted to small diameter trees in conifer plantations.

The Direct and Indirect Effects of Implementing Alternative 1

Forest Vegetation Age Classes, Composition, Structure and Insect and Disease

No vegetative manipulation or habitat improvement projects would occur under Alternative 1, except for on-going activities, such as Forest and County road and public utility rights-of-way maintenance, and research activities; however, resource protection, and suppression of NNIP, insect and diseases to maintain forest health may occur. Individual tree growth and survival, and stand succession, would be subject to environmental and biological factors, such as windstorms, wildfire and insect and disease outbreaks. The forest types and age classes estimated to occur in ten years on NFS lands are found in Table 3-3.

Acres of Forest Type by Age Class in 2024[1] (NFS lands only)
Table 3-3

	Age Classes in Ten Year Groups													
Forest Cover Type	**None**	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**90-99**	**100-110**	**110-149+**	**Acres**
Jack/Scots pine	0	0	0	0	0	22	0	13	5	48	0	0	0	88
Red/white pine	0	0	0	37	17	0	162	478	563	954	81	0	136	2,428
Oak-eastern white pine	0	0	5	0	0	0	0	0	0	118	0	0	113	236
Oak-aspen	0	0	0	0	0	0	39	0	0	0	12	15	10	76
Red/jack pine-oak	0	0	0	0	4	0	0	0	45	93	0	0	0	142
Black/white oak	0	0	0	8	3	53	144	81	17	84	390	159	506	1,445
Mixed oak-red maple	0	0	0	0	0	0	0	39	14	355	406	337	585	1,736
Mixed northern hardwood	0	0	0	0	0	0	0	0	0	0	0	6	155	161
Mixed lowland hardwood/ conifer	0	0	0	0	0	0	0	0	0	0	103	107	0	210
Quaking-bigtooth aspen	0	0	0	50	0	0	32	0	0	123	58	0	0	263
Lowland shrub	126	0	0	0	0	0	0	0	0	0	0	0	0	126
Upland shrub	26	0	0	0	0	0	0	0	0	0	0	0	0	26
Upland opening	739	0	0	0	0	0	0	0	0	0	0	0	0	739
Total	**891**	**5**	**95**	**24**	**75**	**377**	**611**	**644**	**1,775**	**1,050**	**624**	**479**	**1,026**	**7,676**

[1]*Source: FSVegSpatial, acres are approximate.*

The majority of forest types would be older in the next decade, except that older age classes of aspen, aspen-oak, and black-white oak would have sufficient mortality of these species to effect a change in the forest type or vertical structure. The aggregate population of oak trees would remain relatively stable, declining in the larger diameters, but increasing in smaller diameters and becoming more numerous where aspen and over mature oak die out.

The longer-lived upland species (red-white pines and mixed oaks-red maple) would tend to persist as even-aged stands. Red pine is able to maintain high numbers of trees per acre in plantations. As a result, the canopy closes and a thick layer of needles forms on the soil surface, slowing the establishment of ground flora and tree seedlings. Tree diameter growth is slower in dense plantations because incremental growth is spread over a large number of stems per acre. Height growth in dense plantations is less effected than diameter growth, and older plantations that have not been thinned tend to have more wind damage associated with tall, slender pines. Commercial treatments that promote individual stem growth and vigor in plantations, and that convert red pine to young oaks, would not occur under Alternative 1, increasing the susceptibility of the red pines to attack by the sirex woodwasp, wildfires, and windstorms. Oaks on better quality soils live longer than on poor on quality soils, and are more resilient to insect and disease attacks. Better quality soils also have red maple and beech in the understory, which would slowly advance into the over-story on these areas.

Black oaks >100 years old would experience a decline in the over-story as individuals and small groups of oaks die; oak decline would likely cause extensive mortality in stands >110 years old. In these areas, the sunlight pockets created by dead and dying trees would allow a mix of understory species to develop that would consist primarily of white oak and black cherry. On the sites affected by oak decline, mature white oaks would be less affected than black oaks. Without a major disturbance, such as a fire or planting, black oak seedling recruitment on these areas would be difficult. Black and white oaks commonly develop in the understory of pines, where growth is minimal until sufficient sunlight is available for seedlings to grow into saplings and continue to maturity (Burns and Honkala 1990).

Jack pine-oak and jack pine plantations with some large oaks currently in the over-story would continue to recruit oak seedlings and in some cases, these may replace decadent pines. Jack pine would continue to occupy over-story positions in age classes <90 years old. In other cases, little or no oak seedling recruitment is imminent, and a low density of oak and jack pine seedlings would naturally succeed the existing plantations. In contrast, jack pine stands on better quality soils would trend towards uneven-age red maple, oaks, white, or red pine forests as the jack pine trees decline and die out.

Aspen naturally regenerates by producing shoots from the roots after a disturbance, such as a windstorm or wildfire. Aspen stands of advanced age tend to have fewer aspen trees per acre and the root systems of the remaining aspen are weak, and these weakened root systems produce fewer and less aggressive sprouts. If the aspen sprouts cannot compete against other trees (such as stump sprouts from red maple), the less shade tolerant aspen dies out. The population of red maple would increase in aspen stands >60 years old, especially in areas of high water tables; red maple would also increase in the understory of high-site oak-aspen stands. Aspen >99 years old would be considered converted to a different vegetation type. This alternative, with no management of forested stands, would passively convert some aspen to non-aspen cover and vegetation types.

The Project Area contains upland openings that tend to be small, and these openings would decrease modestly in both size and abundance, due primarily to encroachment of oaks, pines and red maple. Alternative 1 would not treat these areas to restore upland opening conditions with either mechanical or prescribed burning; a few areas with considerable encroachment would be naturally converted to young forest conditions.

The Project Area also contains four remnant areas of dry sand prairie (approximately 120 acres) that have not been planted with conifers, or have very little woody vegetation encroachment. Three of these areas are in the Newaygo Prairies RNA, and the fourth (and largest) is the Newaygo Ecological Study Area (ESA). Alternative 1 would not treat these areas to reduce resource damage and NNIP populations that threaten the integrity of these dry sand prairies.

Lowland openings would continue to be influenced by high water tables and/or acidic conditions that favor leatherleaf, willow, alder and dogwood shrubs and cattails, sedge species, and bulrush species. Despite no net change in acres under this alternative, these wetlands would infrequently be affected by natural hydrological cycles that alter woody growth patterns within (and on the edges of) bogs, ponds and streams.

Oak decline would become more widespread as tree vitality decreases; oak wilt would also spread and new infection centers are likely to occur. Oak mortality in the next decade would increase the fuel loading, with a corresponding increase in fire behavior. Local firewood gathering under the Forests' permit system is likely to remove dead oaks within a short distance of Forest and County roads. Areas of red pine pocket mortality and oak wilt would continue to slowly expand, as sanitation harvests (performed concurrently with other commercial harvests) would not occur in this alternative. Mortality from sirex woodwasp would be confined primarily to smaller, weaker red and jack pines; the dynamics of beech bark disease and emerald ash borer infestations would not be affected.

NNIP would persist adjacent to roads, recreation trails, camping areas, and openings, and become established where natural and human disturbances provide new habitat opportunities.

The Cumulative Effects of Implementing Alternative 1

The principle effect of taking no action would be to passively change the structure of aggregate forested stands from even-aged to uneven-aged canopies. This would occur as the acres of long-lived species such as red and white pine and white oak increase, and the acres of jack pine, upland openings, and aspen decrease. Existing upland, non-forested areas, and the prairie remnants within the RNA, would continue be invaded with pines and oaks, and gradually attain forest qualities as these species mature and continue to regenerate in open areas. Infrequent fire, and wind-induced mortality events would interact with natural succession, and result in succession at a local scale (i.e. one to several acres, and less frequently, at scales >10 acres). Forest insect and disease conditions would continue to cause mortality, especially in forested wetlands, over mature low site oaks, and in areas having residential developments. The long-term exclusion of fire disturbance would enhance these structural changes, and favor accumulating those species tolerant of less frequent fires (white pine and white oak) over those species adapted to more frequent fire events (jack pine and black oak). The dominant herbaceous species would persist; existing NNIP would expand in suitable habitats, especially along utility and road rights-of-way. New introductions of NNIP would likely become established, especially adjacent to roads, trails, and open areas on both public and private lands.

Between 1976 and 2013, a variety of vegetation treatments on NFS lands within the Project Area have occurred. These treatments, recorded in the data base of record FACTS, for the period 1976-2013, are summarized in Table 3-4. There is no history of oil and gas production, but there are over 4 miles of regional utility transmission corridors (electric and gas) in the Project Area that are periodically treated to control woody vegetation by the utility owners on NFS lands.

National Forest Vegetation Treatments 1978-2013
Table 3-4

Treatment Type	Acres
Prescribed fire: Fuel reduction and wildlife habitat improvement	316
Regeneration harvest	158
Thinning harvest	699
Establish and improve forest vegetation	62
Upland opening creation or rehabilitation	107
Upland opening improvement	41
NNIP reduction	1
Fisheries habitat improvement	2

[1]*Source: FSVegSpatial, acres are approximate.*

The Forest Plan provides for a 10% increase in the allowable sale quantity (ASQ) from lands suitable for timber production between 2016 and 2025. Because the Project Area contains over 5,700 acres of land suitable for timber management, it is likely that commercial vegetation harvests for wildlife habitat improvement and fuel reduction would occur, especially in forests dominated by red and jack pines, aspen, and oaks if regional and local markets for forest products exist. Few acres of private lands are expected to receive similar vegetation treatments; the most common activity would be mature forest and dead tree salvage harvesting.

The Forest Plan anticipates that approximately 32% of its land suitable for timber production would be treated to achieve vegetative desired conditions in the first decade (USDA 2012c). Because no harvesting would occur in Alternative 1, other areas of suitable forest land on the HMNF may be substituted instead, as displayed in Table D-5 in the Forest Plan.

The existing and potential number of residential and commercial buildings could reduce the amount of total forest cover and increase forest fragmentation on private land. This suggests that the 10,000 acres of hazardous fuels reduction and fuel-break treatments to reduce wildfire potential in the Forest Plan's first decade (and beyond), are likely to be proportionally distributed on NFS lands within the Project Area.

The vegetation composition changes 2014-2024 are displayed in Table 3-5.

Change in Project Area Vegetation Composition 2014-2024
Table 3-5

Vegetation Class	Project Area Existing 2014	Project Area 2024	Net % Change 2014-2024	HMNF Forest Plan Desired in 2016
Aspen/birch	3.4%	2.7%	-0.7%	10-16%
Lowland hardwood and conifer	2.7%	2.7%	0%	0-10%
Long-lived conifer	33.3%	33.3%	0%	17-23%
High-site oak	27.3%	28.0%	+0.7%	15-21%
Opening	9.8%	9.7%	-0.1%	4-10%
Northern hardwood	2.0%	2%	0%	8-14%
Short-lived conifer	1.1%	1.1%	0%	2-8%
Low-site oak	18.9%	19.0%	+0.1%	13-19%
Barren and savanna	1.5%	1.5%	0%	2-5%

Conclusion: The duration and magnitude of taking no action would incrementally add to past, present and reasonably foreseeable vegetation patterns within the MNF, primarily by allowing the existing vegetation to mature or be replaced by late-seral stages of forest vegetation. This effect would be most pronounced on NFS lands, including the RNA. Private forest lands would be expected to be further subdivided for housing development. This fragmentation would reduce the likelihood of private forest management on a large scale. Native and non-native diseases and insects would increase the natural rates of tree mortality, especially in oaks and pines on low quality sites. Accelerated mortality would increase fuel loading, especially in red and jack pine forests; firewood gathering has the potential to remove considerable amounts of dead oak. NNIP and their negative impacts on native vegetation would become more widespread and pronounced. The ecological integrity of the RNA prairies would suffer, and its baseline status could be compromised for research and monitoring purposes.

The Direct and Indirect Effects of Implementing Alternative 2

Age Classes, Insect & Disease, Species, and Structure

Under Alternative 2 vegetative treatments would occur as displayed in Table 2-1. Red pine stands, with an average tree diameter >6 inches and stocking levels exceeding 95%, would be thinned using commercial harvests. Two pine plantations would be commercially harvested to promote the regeneration of oaks. Mechanical site preparation and hand planting would occur in some areas to sustain productivity of regenerated forestland. Some of the pine and oak stands would be converted to dry sand prairie or savanna using commercial harvests. Existing upland, non-forest areas would be maintained using non-commercial methods. Prescribed burning would occur in numerous upland vegetation areas, either separately or in combination with other treatments.

The forest types and age classes estimated on NFS lands in 2024 under Alternative 2 are found in Table 3-6. Even-aged forests of red pine and oaks would be predominant, with more canopy structure occurring in lowland hardwood/conifer and high-site oak stands. Mortality from oak decline is expected to continue, despite conversion of many older black and white oak stands to upland openings.

Mortality to ash species from the emerald ash borer will affect trees in all size classes and change the composition and structure of riparian forests. Infection centers of oak wilt and red pine pocket mortality in stands proposed for commercial harvesting would be identified and sanitation treatments would be included in the harvest prescription. Potential mortality from sirex woodwasp would be reduced in red pine stands identified for commercial thinning; however, beech bark disease and emerald ash borer infestations would not be specifically treated in Alternative 2.

A part of the RNA would be treated with prescribed fires and hand tools to reduce woody species encroachment, and to protect the ecological value of this area for research and monitoring. These treatments would maintain and protect the special characteristics of the remnant prairies by simulating naturally occurring fires that historically maintained them as grassland dominated ecosystems.

Thinning red pine plantations to 80% of full stocking would satisfy individual tree growing needs for 15-20 years, and perpetuate the dominance of red pine in an even-age structure. Thinning would improve the growth of the residual stands, increase the timber value over the long-term, increase tree vitality, decrease risk from pathogen infestation, and promote understory vegetation growth. An even-age structure would be continued when these plantations are thinned, as the majority of trees that are retained are the largest in diameter within each stand. Retained individual oaks, maples, jack pines, and shrubs would provide some species and structural diversity.

Following thinning, a many plantations would also be treated with prescribed fire to further reduce fine fuel loading. The prescribed fires would occur when the slash left after the thinning has sufficiently deteriorated so that the fire consumes the pine litter and understory vegetation. These stands contain species that are adapted to fire and have trees large enough in diameter so that expected tree mortality following the burns is low. However, some species that are more vulnerable to fire (white pine, red maple) would experience higher levels of mortality. The effects

Acres of Forest Type by Age Class 2024[1] - Alternative 2 (NFS lands only)
Table 3-6

	Age Classes in Ten Year Groups													
Forest Cover Type	**None**	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**90-99**	**100-110**	**110-149+**	**Acres**
Jack/Scots pine	0	0	0	0	0	0	0	13	5	48	0	0	0	66
Red/white pine	0	0	0	37	5	0	146	396	551	925	76	0	95	2,231
Oak-eastern white pine	0	0	5	0	0	0	0	0	0	118	0	0	113	236
Oak-aspen	0	0	0	0	0	0	32	0	0	0	12	15	10	59
Red/jack pine-oak	0	0	0	0	4	0	0	0	39	63	0	0	0	106
Black/white oak	0	45	0	8	3	53	128	81	17	68	376	157	387	1,323
Mixed oak-red maple	0	0	0	0	0	0	0	30	14	346	405	326	477	1,598
Mixed northern hardwood	0	0	0	0	0	0	0	0	0	0	0	0	161	161
Mixed lowland hardwood/ conifer	0	0	0	0	0	0	0	0	0	0	103	107	0	210
Quaking-bigtooth aspen	0	0	0	50	0	0	32	0	0	123	58	0	0	263
Lowland shrub	126	0	0	0	0	0	0	0	0	0	0	0	0	126
Upland shrub	26	0	0	0	0	0	0	0	0	0	0	0	0	26
Upland opening	1,271	0	0	0	0	0	0	0	0	0	0	0	0	1,271
Total	**1,423**	**45**	**5**	**95**	**12**	**53**	**338**	**520**	**626**	**1,691**	**1,030**	**605**	**1,243**	**7,676**

[1]*Source: FSVegSpatial, acres are approximate.*

of prescribed fire on existing hardwood regeneration, primarily oaks, would result in the top-killing of seedlings and saplings. However, hardwood regeneration, and especially oak seedlings and saplings, survive by sprouting from the root collar after the fire.

Two red pine stands would be regenerated using overstory removal harvests. This type of harvest is designed to regenerate mature stands by releasing established oak seedlings from the dominance of the mature trees. After removal of the mature pines, trees from 1 to 5 inches in diameter would be treated with either hand tools or prescribed fire to promote natural regeneration and provide additional vegetative sprouting. Prescribed fire would affect existing regeneration and post regeneration response by favoring oaks over pines. Supplemental pine and oak seedlings would be planted where adequate natural seedling densities are not obtained within the first decade following the overstory removal treatment. An even-age structure would result when these pine and oak areas are regenerated using this combination of treatments. Retained individual oaks, pines, and shrubs would provide some species and structural diversity.

NFS lands managed for timber products are classified as suitable for timber management (Land Suitability Class (LSC) 500). Areas previously having 10% or more tree cover and are developed for non-forest use are classified as non-forest (LSC 200). Some forested land, currently proposed for other emphasis (LSC 600), would be converted to non-forest (barrens/savanna) in order to achieve other Forest Plan goals; this would change the LSC in some areas as shown in Table 3-7. Lands within the RNA (LSC 300) or Experimental Forest (LSC 820) would not be re-classified, despite the planned vegetation treatments.

Change in Land Suitability Class - Alternative 2
Table 3-7

Compartment	Stand	Proposed Action	Acres	Current LSC	New LSC
513	8	Create savanna/opening	13	500	200
517	16	Create savanna/opening	3	500	200
517	23	Create savanna/opening	37	500	200
517	29	Create savanna/opening	11	500	200
517	62	Create savanna/opening	3	500	200
517	67	Create savanna/opening	8	500	200
519	15	Create savanna/opening	1	600	200
519	25	Create savanna/opening	5	500	200
519	26	Create savanna/opening	5	500	200
519	27	Create savanna/opening	2	500	200
519	28	Create savanna/opening	4	500	200
519	29	Create savanna/opening	1	500	200
519	33	Create savanna/opening	22	500	200
519	34	Create savanna/opening	5	500	200
519	40	Create savanna/opening	17	500	200

Compartment	Stand	Proposed Action	Acres	Current LSC	New LSC
519	42	Create savanna/opening	3	500	200
519	43	Create savanna/opening	12	500	200
520	9	Create savanna/opening	8	500	200
520	11	Create savanna/opening	15	600	200
520	12	Create savanna/opening	14	600	200
521	13	Create savanna/opening	21	500	200
521	17	Create savanna/opening	9	500	200
521	25	Create savanna/opening	35	600	200
521	27	Create savanna/opening	43	600	200
576	4	Create savanna/opening	20	500	200
576	6	Create savanna/opening	10	500	200
576	10	Create savanna/opening	6	500	200
576	13	Create savanna/opening	4	500	200
576	16	Create savanna/opening	1	500	200
576	17	Create savanna/opening	1	500	200
576	19	Create savanna/opening	1	500	200
576	22	Create savanna/opening	27	500	200
576	25	Create savanna/opening	6	500	200
578	6	Create savanna/opening	11	500	200
582	7	Create savanna/opening	11	600	200
582	8	Create savanna/opening	9	600	200
586	25	Create savanna/opening	9	500	200

Some forested areas dominated by pines and oaks would be converted to upland openings, including dry sand prairies, using commercial harvesting. This treatment would alter species composition by reducing the density of pine and oak trees, and favor development of herbaceous and shrub species. The canopy layer would be reduced to approximately 0-20%, resulting in a less dense pattern of individuals/groups, thereby increasing exposure of the herbaceous layer to full sunlight. All of these areas could be treated with prescribed fire to promote natural regeneration of desired woody and herbaceous species. A one-canopy layer, with a small population of pine and oaks in savannas and no trees in dry sand prairies, would form a ground cover of herbaceous plants, would form an even-age structure. Native grasses, forbs, and shrub species may be seeded and/or planted to increase species diversity and augment sparse populations of native grasses and forbs. These stands would be removed from the Forests' timber base and become managed openings.

Culmination of Mean Annual Increment

The stands proposed for regeneration treatments would comply with the National Forest Management Act of 1976, Section 6(m). This requires that stands of trees shall generally have reached 95% of the culmination of the mean annual increment (CMAI) (cubic foot measurement/year) prior to harvesting activities, unless there is a project-specific exception to this requirement. This requirement would be met for all stands except for those listed in Table 3-8.

Project Specific Exceptions to CMAI - Alternatives 2 and 3
Table 3-8

Compartment	Stand	Species Group	Current Age	CMAI Age	Reason
517	11	Red pine	78	NA	Wildlife habitat
517	17	Red pine-jack pine	78	NA	Wildlife habitat
All Compartment-stands listed in Table 3-7, Table 3-12					Wildlife habitat

Included in Table 3-8 are those areas identified to be converted from forest to non-forest land in Table 3-7 and Table 3-12.

Other Vegetation Treatments

Upland opening maintenance would occur through a combination of hand tools, mechanical equipment, herbicide application, and controlled burning. The purpose of these treatments would be to simulate growth of desired grasses and forbs and discourage encroachment of small trees and the abundance of Pennsylvania sedge and NNIP.

The proposed thinning and regeneration harvests would reduce the impacts of native and non-native insects and diseases on the pines and oaks within the Project Area; beech and ash trees in the Project Area would continue to be affected by beech bark disease and the emerald ash borer. The sirex woodwasp would have fewer small diameter pines to potentially colonize, and the jack pine budworm would have smaller numbers of mature jack pines to infest when their population periodically increase. Oak wilt infection areas would be identified and harvested (sanitized), thus disrupting root graft spread of this disease within mature oak tree populations, because oak seedlings do not root graft with mature trees, and the fungus is thus deprived of suitable host trees. Spring wounding of oak trees would be reduced by performing all regeneration harvests during the dormant season (October-March), providing fewer avenues for overland spread of spores. Oak decline mortality would be reduced by having a smaller population of stressed, over mature oaks most susceptible to two-lined chestnut borers and root diseases.

Ground disturbance from timber harvesting would occur in the stands proposed for harvest. This disturbance, coupled with the opening of the canopy in these units, would potentially create habitat that would encourage the colonization or spread of NNIP. Existing levels of NNIP infestations are likely to be increased in the more heavily disturbed areas of the project, especially in landings and

road reconstruction areas. Road maintenance equipment and recreation uses would continue to serve as introduction and dispersal vectors along utility, road, and trail corridors. Equipment cleaning clauses in federal timber contracts would reduce the potential for logging equipment to spread NNIP to relatively un-infested sites. After timber harvest activities are completed, heavily disturbed sites, (landings and temporary roads), would be rehabilitated to encourage re-vegetation and minimize the potential for new introductions and the spread of invasive species. The proposed NNIP control treatments would reduce the potential of these species to increase following implementation of the proposed treatments; monitoring of previous projects has shown this mitigation to be effective. The proposed treatments also help to slow, or eliminate, the spread of existing NNIPs that aggressively out compete and replace native vegetation.

The Cumulative Effects of Implementing Alternative 2

The principle effect of the proposed action would be to retain approximately 81% of the forest canopy structure of aggregate forested stands in even-aged canopies. This would occur as the long-lived species, such as red and white pine, are thinned, and black and white oaks are regenerated. Thinning perpetuates the existing even-age canopy structure, without changing the forest cover type; regenerating black and white oaks reduces multi-age canopies from developing in mature forest stands. Forest areas dominated by mixed oaks and lowland hardwoods and conifers would continue to develop more diverse structural features. Existing upland, non-forested areas would increase because of both active and passive treatments that reduce forest cover. Infrequent fire, and wind-induced mortality events would interact with natural succession, and result in succession at a local scale (i.e. one to several acres, and less frequently, at scales >10 acres). Forest insect and disease conditions would continue to cause mortality, especially in forested wetlands, and also in over mature low site oaks, and in areas near residential developments. However, a small amount of oak mortality can be expected in oak stands <50 years. The amount of broadcast prescribed burning would substitute for a lack of wildfire disturbance and enhance structural changes, and favor accumulating those species tolerant of this disturbance (red pine and black-white oaks) over those species adapted to less frequent fire events (white pine, red maple). The dominant herbaceous species would persist, and uncommon species would become more numerous in restored dry sand prairies and savannas. Existing populations of cypress spurge would be reduced, but other NNIP populations, especially common St. John's-wort and spotted knapweed, would remain in some forested areas, and along utility and road rights-of-way. New introductions of NNIP would likely become established, especially adjacent to roads, trails, and open areas on both public and private lands.

The RNA prairie ecosystem would be protected in two locations by using prescribed fires and handtools to simulate naturally occurring wildfires. NNIP populations within the RNA would be treated and monitored annually for additional herbicide and hand pulling for a 10 year period.

Between 1978 and 2013, a variety of vegetation treatments on NFS lands within the Project Area have occurred. These treatments, recorded in the data base of record FACTS, for the period 1978-2013, are summarized in Table 3-5.

The vegetation composition changes 2014-2024 resulting from the proposed action are displayed in Table 3-9.

The Forest Plan provides for a 10% increase in the ASQ from lands suitable for timber production between 2016 and 2025. Because the Project Area would still contain approximately 5,700 acres

of land suitable for timber management, it is likely that vegetation management for wildlife habitat benefits and timber products would occur, especially in forests dominated by red pine and oaks if regional and local markets for forest products exist. Few acres of private lands are expected to receive similar vegetation treatments; the most common activity would be mature forest and dead tree salvage harvesting.

Change in Project Area Vegetation Composition 2014-2024 - Alternative 2
Table 3-9

Vegetation Class	Project Area Existing 2014	Project Area 2024	Net % Change 2014 - 2024	HMNF Forest Plan Desired in 2016
Aspen/birch	3.4%	3.4%	0.0%	10-16%
Lowland hardwood and conifer	2.7%	2.7%	0%	0-10%
Long-lived conifer	33.3%	30.4%	-2.8%	17-23%
High-site oak	27.3%	24.7%	-2.6%	15-21%
Opening	9.8%	10.2%	+0.4%	4-10%
Northern hardwood	2.0%	2.0%	0%	8-14%
Short-lived conifer	1.1%	0.9%	-0.2%	2-8%
Low-site oak	18.9%	17.2%	-1.7%	13-19%
Barren and savanna	1.5%	8.5%	+7.0%	2-5%

The existing and potential number of residential and commercial buildings could reduce the amount of total forest cover and increase forest fragmentation. This suggests that the 10,000 acres of hazardous fuels reduction and fuelbreak treatments to reduce wildfire potential in the Forest Plan's first decade (and beyond), are likely to be proportionally distributed on NFS and private lands within the Project Area.

The Forest Plan anticipates that approximately 32% of its land suitable for timber production would be treated to achieve vegetative desired conditions in the first decade (USDA 2012c). The amount of suitable forest land proposed for conversion to openings in Alternative 2 is proportional to that displayed in Table D-5, and would have effects on the ASQ of the HMNF as discussed in the Forest Plan.

Conclusion: The duration and magnitude of the proposed action would incrementally add to past, present and reasonably foreseeable vegetation patterns within the MNF, primarily by allowing approximately 81% of the existing forest vegetation to mature or be replaced by late-seral stages of

Comparison of Vegetation Treatments - Alternatives 2 and 3
Table 3-10

Treatment Activity Group	Vegetation Treatment Activities and Forest Types	Alt 2 Acres (# of locations)	% of Project Area	Alt 3 Acres (# of locations)	% of Project Area
Regenerate Forest Cover	Overstory removal: Convert mixed pine and red pine to black and white oak.	45 (2)	0.6	45 (2)	0.6
Opening & Savanna Creation	Convert red/white/mixed pine, and black/mixed oak.	587 (43)	7.6	335 (30)	4.4
Prescribed Fire	Broadcast burn in upland openings, red/white/mixed pine, red pine/oak, and black/white/mixed oak.	696 (33)	9.1	746 (33)	9.7
Opening Restoration	Maintenance of upland openings.	345 (40)	4.5	343 (39)	4.5
Intermediate Harvest to Perpetuate Forest Cover	Thinning: Red pine, red pine-oak, mixed pine.	1,412 (57)	18.4	1,457 (57)	19.0
Total Acres		3,085 (175)	40.2	2,926 (161)	38.1

Acres of Forest Type by Age Class in 2024[1] - Alternative 3 (NFS lands only)
Table 3-11

	Age Classes in Ten Year Groups													
Forest Cover Type	**None**	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**90-99**	**100-110**	**110-149+**	**Acres**
Jack/Scots pine	0	0	0	0	0	0	0	13	5	48	0	0	0	66
Red/white pine	0	0	0	37	5	0	157	463	551	930	76	0	95	2314
Oak-eastern white pine	0	0	5	0	0	0	0	0	0	118	0	0	113	236
Oak-aspen	0	0	0	0	0	0	32	0	0	0	12	15	10	59
Red/jack pine-oak	0	0	0	0	4	0	0	0	39	63	0	0	0	106
Black/white oak	0	45	0	8	3	53	128	81	17	84	376	157	387	1339
Mixed oak-red maple	0	0	0	0	0	0	0	30	14	346	405	326	574	1695
Mixed northern hardwood	0	0	0	0	0	0	0	0	0	0	0	0	161	161
Mixed lowland hardwood/ conifer	0	0	0	0	0	0	0	0	0	0	103	107	0	210
Quaking-bigtooth aspen	0	0	0	50	0	0	32	0	0	123	58	0	0	263
Lowland shrub	126	0	0	0	0	0	0	0	0	0	0	0	0	126
Upland shrub	26	0	0	0	0	0	0	0	0	0	0	0	0	26
Upland opening	1075	0	0	0	0	0	0	0	0	0	0	0	0	1075
Total	**1227**	**45**	**5**	**95**	**12**	**53**	**349**	**587**	**626**	**1712**	**1030**	**605**	**1340**	**7676**

[1]*Source: FSVegSpatial, acres are approximate.*

forest vegetation. This effect would be most pronounced on NFS lands. Private forest lands would be expected to be further subdivided for housing development. This fragmentation would reduce the likelihood of private forest management on a large scale. Native and non-native diseases and insects would increase the natural rates of tree mortality, especially in mature oaks and pines on low quality sites, and ashes in riparian sites. Accelerated mortality would increase fuel loading, especially in oak and red pine forests; firewood gathering has the potential to remove large quantities of dead oak. NNIP and their negative impacts on native vegetation would become more widespread and pronounced. The RNA ecological values would be protected and continue to meet its establishment objectives.

The Direct and Indirect Effects of Implementing Alternative 3

Age Classes, Insect & Disease, Species, and Structure

The amounts of vegetative treatments proposed in Alternative 3 are different in both scale and locations of those proposed in Alternative 2; Table 3-10 displays the amount of vegetation treatments for Alternatives 2 and 3.

The Vegetation Treatment Activity Groups in Table 3-10 summarize the similar treatments to forest and non-forest areas as described in Alternative 2 above, and would have similar effects to the structure and species composition of forest vegetation that are detailed there. The principal differences between proposed treatments in Alternatives 3 are the total amounts and spatial arrangement of conifer thinning and upland openings created and maintained. There are also differences between these alternatives for the amounts and locations of proposed prescribed fire treatments. Table 3-11 displays the effects of the proposed treatments.

Culmination of Mean Annual Increment

The stands proposed for regeneration treatments would comply with the National Forest Management Act of 1976, Section 6(m). This requires that stands of trees shall generally have reached 95% of the CMAI (cubic foot measurement/year) prior to harvesting activities, unless there is a project-specific exception to this requirement.

The two pine plantations proposed for regeneration harvest (overstory removal) have not reached or exceeded the rotation age guidelines of the Forest Plan (II-17) as displayed in Table 3-8. Also included in Table 3-8 are those areas identified to be converted from forest to non-forest land in Table 3-12.

Some forested land, currently identified as suitable for timber management, would be converted to non-forest land (upland opening) in order to achieve other Forest Plan’s goals; this would change the LSC in some areas as shown in Table 3-12. The proposed treatments in this alternative would have similar effects, as described in Alternative 2, to reduce the impacts of native and non-native insects and diseases on the pines and oaks within the Project Area.

The proposed treatments in this alternative would have similar effects, as described in Alternative 2, to affect the impacts of NNIP within the Project Area. However, slightly fewer acres of ground disturbing activities would decrease somewhat the potential for existing or new infestations to spread or occur in Alternative 3 as compared to Alternative 2.

Change in Land Suitability Class - Alternative 3
Table 3-12

Compartment	Stand	Proposed Action	Acres	Current LSC	New LSC
513	8	Create savanna/opening	13	500	200
517	16	Create savanna/opening	3	500	200
517	23	Create savanna/opening	37	500	200
519	33	Create savanna/opening	22	500	200
519	34	Create savanna/opening	5	500	200
519	40	Create savanna/opening	17	500	200
519	42	Create savanna/opening	3	500	200
519	43	Create savanna/opening	12	500	200
520	9	Create savanna/opening	8	500	200
520	11	Create savanna/opening	15	600	200
520	12	Create savanna/opening	14	600	200
521	13	Create savanna/opening	21	500	200
521	17	Create savanna/opening	9	500	200
576	4	Create savanna/opening	20	500	200
576	6	Create savanna/opening	10	500	200
576	10	Create savanna/opening	6	500	200
576	13	Create savanna/opening	4	500	200
576	16	Create savanna/opening	1	500	200
576	17	Create savanna/opening	1	500	200
576	19	Create savanna/opening	1	500	200
576	22	Create savanna/opening	27	500	200
576	25	Create savanna/opening	6	500	200
578	6	Create savanna/opening	11	500	200
582	7	Create savanna/opening	11	600	200
582	8	Create savanna/opening	9	600	200
586	25	Create savanna/opening	9	500	200

The Cumulative Effects of Implementing Alternative 3

The vegetation composition changes 2014-2024 resulting from Alternative 3 are displayed in Table 3-13.

Change in Project Area Vegetation Composition 2014-2024 - Alternative 3
Table 3-13

Vegetation Class	Project Area Existing 2014	Project Area 2024	Net % Change 2014 - 2024	HMNF Forest Plan Desired in 2016
Aspen/birch	3.4%	3.4%	0.0%	10-16%
Lowland hardwood and conifers	2.7%	2.7%	0%	0-10%
Long-lived conifers	33.3%	33.2%	-0.1	17-23%
High-site oaks	27.3%	22.9%	-4.4%	15-21%
Openings	9.8%	9.8%	0%	4-10%
Northern hardwood	2.0%	2.0%	0%	8-14%
Short-lived conifers	1.1%	0.9%	-0.2%	2-8%
Low-site oaks	18.9%	18.8%	-0.1%	13-19%
Barrens and savannas	1.5%	5.9%	+4.4%	2-5%

The acres selected to be converted to openings would be about 30% fewer, while thinning acres would be slightly larger than in Alternative 2. The principle effect of Alternative 3 would be to retain approximately 84% of the forest canopy structure of aggregate forested stands in even-aged canopies as compared to the No Action Alternative; this is essentially the same effect as in Alternative 2. This would occur as red and white pines are thinned and continue to mature, some pines are converted to oak, and oaks continue to mature and mortality is slight. Thinning perpetuates the existing even-age canopy structure, without changing the forest cover type; regenerating oaks reduces multi-age canopies from developing in mature forest stands. Existing upland, non-forested areas would increase because of both active and passive treatments that reduce forest cover. Infrequent fire, and wind-induced mortality events would interact with natural succession, and result in succession at a local scale (i.e. one to several acres, and less frequently, at scales >10 acres). Forest insect and disease conditions would continue to cause mortality, especially in forested wetlands, over mature low site oaks, and in areas having residential developments. However, some small scale reduction in oak mortality can be expected where the average age of oak trees is <50 years. The amount of broadcast prescribed burning would substitute for a lack of wildfire disturbance and enhance the structural composition of areas burned and favor accumulating those species tolerant of this disturbance (red/ jack pines and white/ black oaks) over those species adapted to less frequent fire events (white pine and red maple). The dominant herbaceous species would persist; existing populations of some would be reduced, but

other NNIP populations, especially autumn olive, would remain in some forested areas, and along utility and road rights-of-way. New introductions of NNIP would likely become established, especially adjacent to roads, trails, and open areas on both public and private lands.

The treatments summarized in Table 3-4, are accumulative to those proposed in Alternative 3.

The Forest Plan provides for a 10% increase in the ASQ from lands suitable for timber production between 2016 and 2025. Because the Project Area would still contain over 5,700 acres of land suitable for timber management, it is likely that vegetation management for wildlife habitat benefits and timber products would occur, especially in forests dominated by red and jack pines, aspen, and oaks if regional and local markets for forest products exist. Few acres of private lands are expected to receive similar vegetation treatments; the most common activity would be mature forest and dead tree salvage harvesting.

The Forest Plan anticipates that approximately 32% of its land suitable for timber production would be treated to achieve vegetative desired conditions in the first decade (USDA 2012c). The amount of suitable forest land proposed for conversion to openings in Alternative 3 is proportional to that displayed in Table D-5, and would have effects on the ASQ of the HMNF as discussed in the Forest Plan.

The existing and potential number of residential and commercial buildings could reduce the amount of total forest cover and increase forest fragmentation. This suggests that the 10,000 acres of hazardous fuels reduction and fuelbreak treatments to reduce wildfire potential in the Forest Plan's first decade (and beyond), are likely to be proportionally distributed on NFS and private lands in the Project Area.

The RNA prairie ecosystem would be protected in two locations by using prescribed fires and handtools to simulate naturally occurring wildfires. NNIP populations within the RNA would be treated and monitored annually for additional herbicide and hand pulling for a 10 year period.

Conclusion: The duration and magnitude of the Alternative 3 would incrementally add to past, present and reasonably foreseeable vegetation patterns within the MNF, primarily by allowing approximately 84% of the existing vegetation to mature or be replaced by late-seral stages of forest vegetation. This effect would be most pronounced on NFS lands. Private forest lands would be expected to be further subdivided for housing development. This fragmentation would reduce the likelihood of private forest management on a large scale. Native and non-native diseases and insects would increase the natural rates of tree mortality, especially in mature oaks and pines on low quality sites. Accelerated mortality would increase fuel loading, especially in red and jack pine forests; firewood gathering has the potential to remove large quantities of dead oak. NNIP and their negative impacts on native vegetation would become more widespread and pronounced. The RNA ecological values would be protected and continue to meet its establishment objectives.

Aquatic Resources

Analysis Area

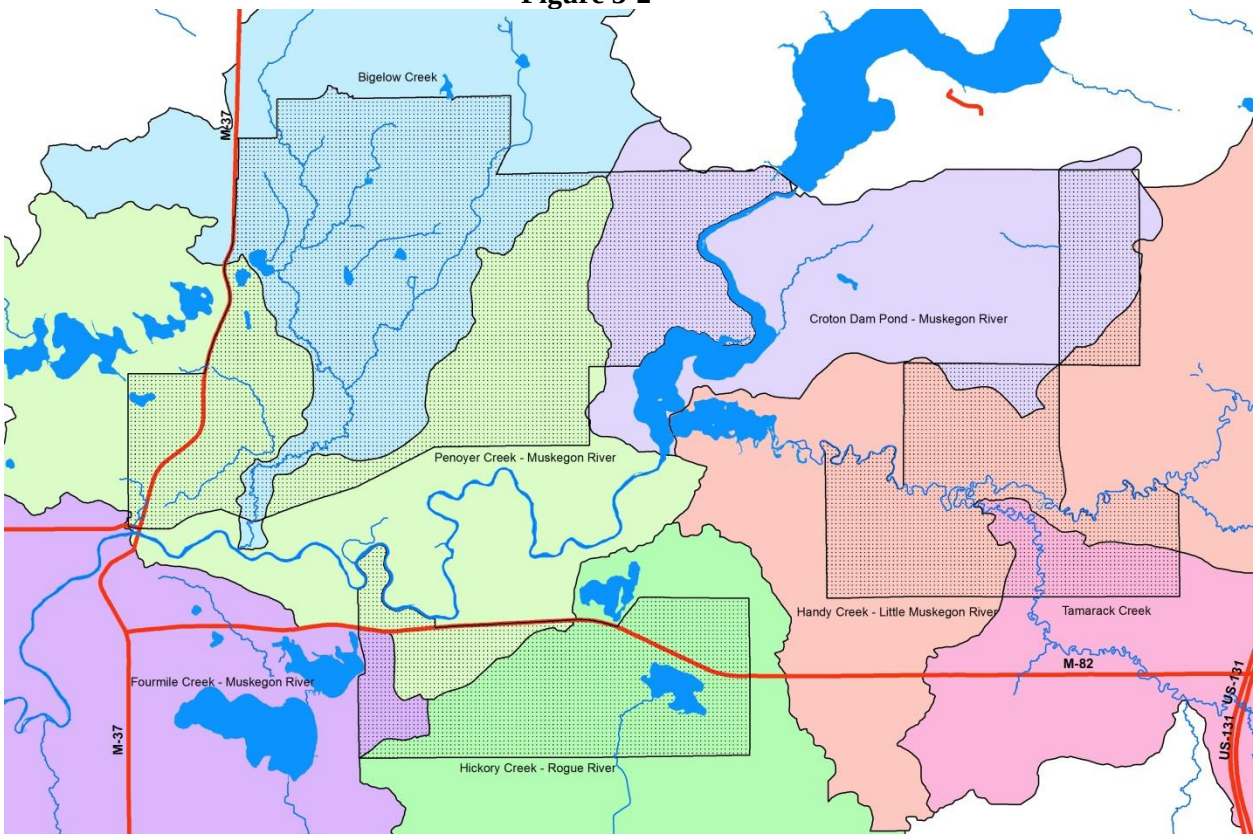
The area of analysis for cumulative effects under all alternatives is defined by the combined outer boundary of the seven 6th code sub-basins that the project occurs in (Figure 3-2). This area was selected because all proposed activities occur within these watersheds and the effects of these

activities should be limited to these areas. Cumulative effects are discussed for the foreseeable future, which is approximately 10 years.

Existing Condition

The Bigelow-Newaygo Project Area occurs within seven 6th code sub-basins of the Muskegon River basin: Bigelow Creek, Penoyer Creek-Muskegon River, Croton Dam Pond-Muskegon River, Fourmile Creek-Muskegon River, Hickory Creek-Rogue River, Tamarack Creek, and Handy Creek-Little Muskegon River (Figure 3-2). There are seven lakes or large ponds occurring within the Project Area, including Bills Lake, Crofoot Lake, Twinwood Lake, Little Lake Placid, Abeys Lake, Toft Lake, and Utley Lake. The project boundary runs adjacent to portions of the Muskegon River including Croton Dam Pond and Hardy Dam Pond, which are not included in the Project Area.

Map of the Seven 6th Code Sub-basins Occurring within the Project Area
(The sub-basins are shown by color; the Project Area is the stippled polygons.)
Figure 3-2



The rivers and tributaries within the Project Area are typically ground water fed with stable flow, good water quality, and generally carry a relatively low-to-moderate sediment load dominated by sand-sized particles. Historic human uses such as timber harvest, log drives, removal of wood debris, draining of wetlands and loss of beaver habitat, along with the more recent development of agricultural lands and road density have impacted channel function to varying degrees.

The watersheds in the Project Area exist within a fragmented landscape, in regard to both hydrology (dams, increasing road density, loss of wetlands, etc.) and forest cover. Most forms of hydrologic fragmentation tend to narrow and heighten the flood hydrograph, increasing the risk of damage to stream bank integrity, channel morphology, aquatic habitat, and facilities located in the riparian/floodplain zone. Dams and constructed features that function to dam water and sediment (i.e. road crossings) are one form of fragmentation that generally reduce the risk of flood impacts, but do have considerable impacts upon sediment regimes and biological processes, particularly species migration/population connectivity, timing of water delivery, and water temperature.

Forest cover fragmentation occurs over space and time as a result of natural processes (wildfire, wind events, other natural disturbances), but can be augmented when human management (timber harvest, agricultural and urban land clearing, road building, etc.) increases the quantity and rate of fragmentation. Typically, mature forested stands protect integrity, whereas increasing proportions of open land cover and immature stands (<15 years old) have negative impacts to watershed function (Verry 2001) and biological function (Steen et al 2010, Wiley et al 2010).

Such impacts affect the rate of runoff, leading to flashier flows and changes in channel morphology. The Forest Plan addresses this issue of forest cover impacts to watershed function with a Desired Future Condition (DFC) of no more than 66% of any 6th code watershed on the HMNF being in early successional (open or immature) forest cover types. The existing percent open area in all seven 6th code sub-basins of the Project Area are within the DFC (Table 3-14).

Roads (open and closed to the public) and motorized trails are another form of fragmentation that negatively impact streams and wetlands in a number of ways. As with open space, roads can accelerate the rate of runoff, and may also intercept and divert subsurface flow, reduce groundwater recharge, and indirectly lead to the conversion of wetland vegetation types to upland types (Jones and Grant 1996). Where roads or trails cross streams, upstream migration of aquatic organisms and channel function can be limited where inappropriately designed or constructed

Early Successional Forest Cover (Open Area)[1] in the Six 6th Code Sub-basins of the Project Area - Alternative 1

Table 3-14

6th Code Watershed	Watershed Acres	Existing Open Acres	Existing Percent Open Area
Bigelow Creek	20,210	4,797	24
Penoyer Creek-Muskegon River	26,849	8,471	32
Croton Dam Pond-Muskegon River	12,358	2,338	19
Fourmile Creek-Muskegon River	22,006	9,562	43
Hickory Creek-Rogue River	33,682	19,453	58
Handy Creek-Little Muskegon River	37,451	13,429	36
Tamarack Creek	25,739	13,941	54

[1]*Percent open area is quantified from current HMNF's GIS data.*

crossing structures create physical barriers. There are a number of such barrier culverts in the Project Area, particularly in the Bigelow Creek watershed. Road and trail crossings also act as point sources of fine sediment delivered to streams that can impact habitat important to a wide range of aquatic biota. The density of roads and trails (miles/mile^2) is a relative index of the impacts of roads/trails to aquatic resources, and is reported in Table 3-15. Across the seven 6th code sub-basins of the Project Area, the density of roads and trails is 3.00 miles per square mile of land, with the highest density occurring in the Tamarack Creek (4.14 mi/mi^2) and Fourmile Creek (3.60 mi/mi^2) watersheds, and the least occurring in the Handy Creek-Little Muskegon River watershed (2.27 mi/mi^2).

National direction for assessing watershed condition (USDA 2009a) rates road densities <1.0 mi/mi^2 as "*Good*", 1.0-2.4 mi/mi^2 as "*Fair*", and >2.4 mi/mi^2 as "*Poor*". Using the criteria described in USDA (2009a), watershed condition relative to road density is poor in all seven of the 6th code sub-basins.

Existing Miles and Densities of Roads and Trails Managed by the USFS, MDOT, and Counties, Stratified by 6th Code Sub-basin within the Project Area

Table 3-15

6th Code Sub-basins[1]	USFS Road Miles / Density	County Road Miles / Density	State Road Miles / Density	Total Road Miles / Density	Trail Miles / Density
Bigelow Creek (31.6)	6.3 / 0.20	61.2 / 1.94	3.5 / 0.11	71.0 / 2.25	6.8 / 0.22
Penoyer Creek-Muskegon River (42.0)	3.1 / 0.07	119.9 / 2.85	6.9 / 0.16	129.9 / 3.09	7.3 / 0.17
Croton Dam Pond-Muskegon River (19.3)	3.1 / 0.16	48.1 / 2.49	0.0 / 0.00	51.2 / 2.65	0.0 / 0.00
Fourmile Creek-Muskegon River (34.4)	0.0 / 0.00	111.7 / 3.24	12.3 / 0.20	124.0 / 3.60	0.0 / 0.00
Hickory Creek-Rogue River (52.6)	4.3 / 0.08	127.9 / 2.43	2.8 / 0.05	135.0 / 2.57	12.9 / 0.25
Handy Creek-Little Muskegon River (58.5)	6.0 / 0.10	119.5 / 2.04	5.8 / 0.10	131.3 / 2.24	1.6 / 0.03
Tamarack Creek (40.2)	0.0 / 0.00	145.3 / 3.61	21.1 / 0.52	166.4 / 4.14	0.0 / 0.00
Total (278.6)	22.8 / 0.08	733.6 / 2.64	52.4 / 0.19	808.8 / 2.90	28.6 / 0.10

[1]*Numbers in parentheses are watershed area in square miles.*

Physical and Biological Aquatic Resources

The Forest Plan recognizes 118 fish species and 16 mollusk species occurring within lakes and streams of the HMNF's boundaries. Within the Project Area, State designated trout streams on NFS lands include the eight mile segment of Bigelow Creek, including Twinwood Lake. There are no data available describing the fisheries community in Bills Lake, Crofoot Lake, Little Lake Alice, Abeys Lake, or Toft Lake. The only data describing the fisheries of Utley Lake is from 1926 and lists largemouth bass, bluegill, pumpkinseed sunfish, green sunfish, and Iowa darters,

typical of a warm-water system. Twinwood Lake was surveyed using fyke nets in June 2003 by Forest Service fisheries staff and found to support a diverse community that includes largemouth bass, rock bass, bluegill, pumpkinseed sunfish, redear sunfish, yellow perch, brown bullhead, and Johnny darter. Panfish were most numerous, including yellow perch which historically were not a large component of the community. One brook trout was recorded and carp were noted as numerous and spawning in the shallows of the lake. Water quality data for Twinwood Lake collected in 1969 (Table 3-16) indicate a maximum depth of 21 feet with a thermocline at about 15 feet of depth. No data is available describing other lakes and their respective water quality in the Project Area.

Physical and Water Quality Characteristics of Twinwood Lake, Measured on August 19, 1969, Newaygo County, MI

Table 3-16

Depth (ft)	Temperature (°C)	pH	O_2 (ppm)	Alkalinity (ppm)	PO_4 (ppm)	NO_2 (ppm)	NO_3 (ppm)
Surface (1969)	23.4	9.6	8.4	136	NA	NA	NA
Surface (2003)	NA	*8.3*[1]	NA	NA	*0.01*	*0.015*	*0.13*
3	23.0	NA	NA	NA	NA	NA	NA
5 (2003)	NA	*7.9*	NA	NA	*0.06*	*0.05*	*0.21*
6	21.2	NA	6.8	NA	NA	NA	NA
9	18.0	NA	NA	NA	NA	NA	NA
12	16.5	NA	4.8	NA	NA	NA	NA
15	15.5	NA	NA	NA	NA	NA	NA
18	15.0	NA	3.6	NA	NA	NA	NA
21	14.9	9.2	NA	136	NA	NA	NA

[1]*Values in italics were measured on June 25, 2003.*

Bigelow Creek

Bigelow Creek is a cold-water tributary of the Muskegon River below Croton Dam and provides important spawning and rearing habitat for potadromous species such as steelhead and salmon. It is also a State-designated trout stream. In August 2003, Forest Service fisheries staff electrofished Bigelow Creek in two parcels located in T13N R12W. The southern (downstream) survey reach is 1000 feet long and located in Section 33 immediately downstream of 40th Street, and the northern (upstream) survey reach is also 1000 feet long and located in Section 16 immediately upstream of Walnut Avenue and 24th Street. Results comparing single pass number of fish caught are reported in Table 3-17. Water temperatures in the two reaches were fairly cold and stable on the two days these reaches were sampled, varying from 60-62° F.

Survey data indicate that the fish community in Bigelow Creek is composed of brook trout, brown trout, rainbow (steelhead) trout, blacknose dace, and an undetermined species of sculpin. The population of trout in the downstream reach is roughly 8 times more abundant than the trout

population in the upstream survey reach, and the lower reach is dominated by brown and rainbow (steelhead) trout that tend to be migratory, whereas the upper reach is dominated by brook trout that tend to be less migratory with very few brown or rainbow trout. This relatively great disparity may be due to the high degree of fragmentation between the two reaches where four road-stream crossings function as partial to full barriers to upstream migration. There are a total of nine road-stream crossings identified in the Project Area that would benefit from replacement to provide for aquatic organism passage and/or reduction in sediment delivery to the stream channel.

Number of Fish Caught and Their Numeric Proportions, Sections 16 and 33, Bigelow Creek, 2003

Table 3-17

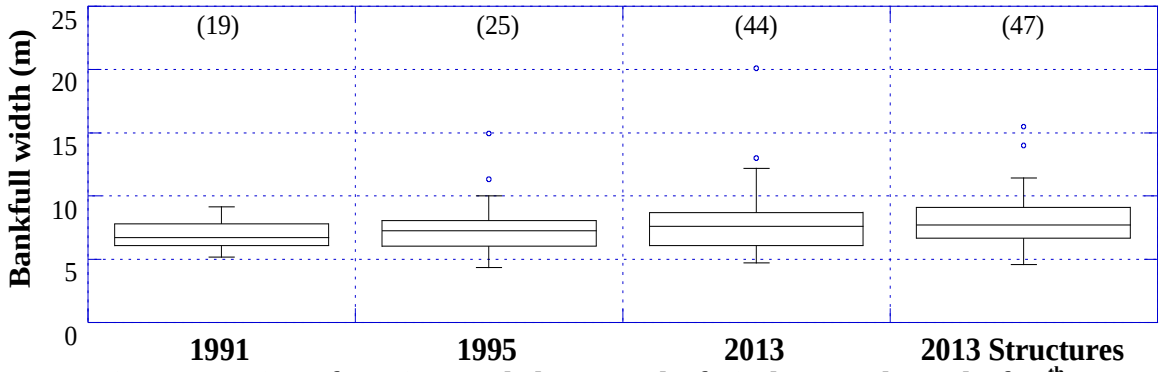
Common name	Section 33 Reach 2003	Percent of total abundance	Section 16 Reach 2003	Percent of total abundance
Brook trout	3	1.4	23	88.5
Brown trout	113	54.6	2	7.7
Rainbow trout	91	44.0	1	3.8
Blacknose dace	Present	NA	Present	NA
Sculpin species	Present	NA	Present	NA
TOTAL	**207**	**100**	**26**	**100**

District fisheries files indicate that wood structures were installed in Bigelow Creek sometime after 1991 in Section 9, and that additional structures were installed in Sections 16 and 33 after May of 2004. Habitat surveys of Bigelow Creek in the segment downstream of 58th Street (Section 9) were conducted in 1991, 1995, and 2013. Comparable data among these surveys include bankfull width and percent substrate composition, along with maximum thalweg depth and maximum pool depth as measured in 1995 and 2013. Other habitat data collected during these surveys are not reasonably comparable.

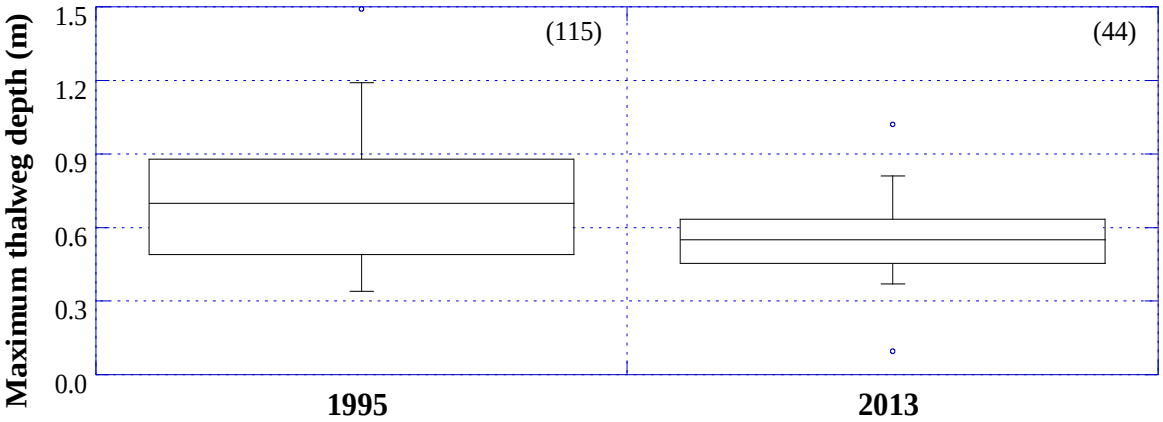
Figures 3-3 and 3-4 provide a comparison of boxplot distributions of bankfull width and maximum thalweg depth. The general trend in bankfull width has been a slight yet gradual increase from 1991 to 2013, and that maximum thalweg depth has decreased since 1995. In contrast, Figure 3-5 relates that the distribution of maximum pool depth has increased from 1995 to 2013, although the number of pools identified is less than half of those measured in 1995. It should be noted that 27 of the 29 pools inventoried in the 2013 survey were associated with wood structures and indicates that these structures were effective at providing vertical scour.

This lesser number of pools observed in 2013 could be due to differences in observer pool recognition by different inventory protocols and/or observers. The 1995 survey does not provide a definition for pools, and in 2013 pools were identified based on having to be a channel-spanning habitat feature and having a greater maximum depth than rifflecrest depth. Rifflecrest depth is a simple measure of the maximum depth at the downstream hydraulic control of the pool and was not measured in 1995 or 1991. If rifflecrest depth had been measured in the 1991 and 1995 surveys, then residual pool depth - a valuable index of channel bed resistance relative to

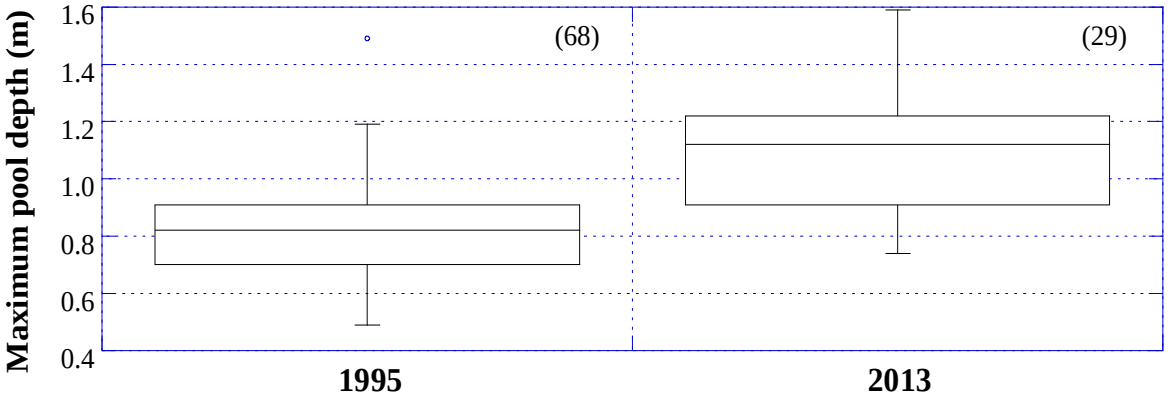
Comparison Over Time of Bankfull Width of Bigelow Creek South of 58th Street in Section 9
(Numbers in parentheses represent number of measurements.)
Figure 3-3



Comparison Over Time of Maximum Thalweg Depth of Bigelow Creek South of 58th Street in Section 9
(Numbers in parentheses represent number of measurements.)
Figure 3-4



Comparison Over Time of Maximum Pool Depth of Bigelow Creek South of 58th Street in Section 9
(Numbers in parentheses represent number of measurements.)
Figure 3-5



streampower - could have been computed and compared to the value computed from the 2013 survey.

In addition, comparison of the distribution of bankfull widths as measured at sites treated with wood structures and untreated sites in the Section 9 reach (Figure 3-3) relate a slightly greater bankfull width associated with the wood structures. This is likely due to the tendency of wood structures to not only scour vertically, but also laterally, as exhibited by considerable bank erosion observed adjacent (behind) many of these structures in 2013.

These wood structures are generally designed to provide hiding cover to trout, and the general result is that they benefit brown trout to a greater degree than other trout species, likely because these structures emulate undercut bank habitat that adult brown trout prefer as ambush cover of other fish species. Recent monitoring by the Michigan Department of Natural Resources (MDNR) fisheries staff of similar structures installed in 2011 on the Pine River, a cold-water trout fishery, confirmed this pattern by showing a considerable increase in brown trout abundance and biomass, with a general decrease in these values for the brook trout and rainbow trout populations, concluding that these results were likely due to brown trout predation (Tonello 2014).

The Project Area includes portions of Penoyer Creek and Ransom Creek however no data are available describing aquatic species or habitat condition of either stream. Field review of Penoyer Creek indicates that it provides high quality habitat in its lower reaches with an overstory canopy shading cold-water habitat that includes abundant pools and gravel substrate. Basswood Road winds across the top of a narrow ridgeline separating Bigelow and Penoyer Creeks in Section 17, and closely parallels Penoyer Creek for about 500 feet where considerable sediment is introduced to the stream channel from road traffic and blading maintenance.

The Project Area boundary parallels the lower Muskegon River at a number of locations. The fish community of the Muskegon River is quite diverse including relatively large runs of potadromous steelhead and salmon, various trout species, walleye, bass, pike, lake sturgeon, and most other fish species found in rivers of the State (O'Neal 1997). Of the 97 original native species that occurred in the Muskegon River, 79% (77 species) currently remain (O'Neal 1997). The Muskegon River also supports a community of freshwater mussels that have experienced a significant decline in diversity over the last 80 years likely due to the cumulative effects of human settlement and development, in particular dams (Carman and Goforth 2003). The community of amphibian and reptile species that are dependent upon aquatic habitats are also quite common in the Muskegon River and its associated off-channel, riparian, and wetland habitats. Given that none of the proposed activities are closer than 500 feet to the river and have a low risk of directly or indirectly impacting these populations, a detailed description of these biota and associated habitat is not covered in this analysis.

Aquatic Federally-Listed Endangered and Threatened Species and Region 9 Regional Forester's Sensitive Species

There are no federally listed (Threatened or Endangered) or proposed (Threatened, Endangered, Proposed, or Candidate) aquatic species, nor any proposed or designated critical aquatic habitat on the HMNF. The Regional Forester has identified nine sensitive aquatic species that may occur in surface waters of the HMNF (http://www.fs.fed.us/r9/wildlife/tes/docs/rfss_animals.pdf). The species are listed in Table 3-18.

On the HMNF, the channel darter is only known to occur in surface waters draining east into Lake Huron. In Michigan, self-sustaining populations of redside dace only occur in the extreme southeast portion of the State, with disjunct populations in the extreme western Upper Peninsula.

The Michigan Natural Features Inventory (MNFI) reports an additional population somewhere in Osceola County, however its exact location is not described and to date there is no documented occurrence of this species in the waters of the HMNF. Both the redside dace and the channel darter are considered to be absent from the waters of the MNF.

Potential Aquatic Regional Forester's Sensitive Species in the Project Area
Table 3-18

Common name	Scientific name
Redside dace	*Clinostomus elongatus*
Channel darter	*Percina copelandi*
Lake sturgeon	*Acipenser fulvescens*
River redhorse	*Moxostoma carinatum*
Greater redhorse	*Moxostoma valenciennesi*
Pugnose shiner	*Notropis anogenus*
Slippershell	*Alasmidonta viridis*
Black sandshell	*Legumia recta*
Creek heelsplitter	*Lasmigona compressa*

The greater redhorse and pugnose shiner are not known to occur in the Muskegon River (O'Neal 1997) and each of these two species is considered to be outside of the Project Area. Spatially small populations of the river redhorse occur in the Muskegon River immediately downstream of the Project Area and considerably farther upstream (O'Neal 1997) and this species is also determined to not occur in the Project Area. Lake sturgeon is a large migratory fish native to the Great Lakes and connected large river systems. Currently, lake sturgeon are known to occur in the Muskegon River immediately below Croton Dam and farther downstream (O'Neal 1997) and are not known to occur in Bigelow Creek or other tributary waters in the Project Area. Dams are a major impediment to lake sturgeon migration affecting their distribution and abundance in their native range. Non-native sea lamprey occur in the lower Muskegon River and lampricide treatments to control this this species in the Great Lakes region are also toxic to larval lake sturgeon (Boogaard et al 2003, LRBOI 2014).

The creek heelsplitter and the slippershell are R9 Regional Forester's sensitive freshwater mussels both known to prefer headwater stream habitats and potentially could occur in smaller streams of the Project Area. The MNFI database notes the slippershell as occurring in Kent, Montcalm, and Newaygo Counties, but lacks distribution records for the creek heelsplitter. The black sandshell is an R9 Sensitive mussel known to occur in rivers and larger streams of northern Michigan and is identified by MNFI as occurring in Newaygo and Kent counties. Carman and Goforth (2003) surveyed the Muskegon River and select tributaries in the summer of 2002 and compared mussel species diversity, distribution, and abundance with surveys conducted in 1934, identifying considerable declines in each of these parameters over that time period. Within the landscape of the Project Area, two sites in the mainstem Muskegon River were surveyed for mussels along with one site in upper Tamarack Creek outside of the Project Area boundary. No live individual Regional Forester's Sensitive Species (RFSS) mussels were recorded from any of these surveys, although black sandshell valves (shells) were noted at a site in the Muskegon River near the town of Newaygo. Invasive zebra mussels were observed at the two mainstem Muskegon River sites but not at the Tamarack Creek site.

In 2013, mussel surveys were conducted at four sites in Bigelow Creek and one site in Penoyer Creek within the Project Area boundary by a malacologist (Chambers 2013). No live mussels were observed during these surveys, although shell fragments were observed in both creeks suggesting that live mussels have occurred in recent years and more intensive survey of these streams would be useful to confirming the presence or absence of mussels in these two streams. No invasive zebra mussels were observed during any surveys of these two streams. To date, none of the R9 Regional Forester's sensitive mussel species have been documented by surveys in the Project Area.

The Direct and Indirect Effects of Implementing Alternative 1

The area of analysis for direct and indirect effects is defined by the combined outer boundary of the seven 6th code sub-basins that the project occurs in. Under this alternative poorly maintained roads and stream crossings would continue to contribute non-point source pollution - particularly fine sediments - to bodies of water within the Project Area. Poorly designed and/or installed stream crossings would continue to block passage of aquatic organisms and sediment would continue to be routed from the road surface to the respective stream channels. The high density and poor design of many of the roads and trails would continue to fragment the watersheds and degrade their conditions. In-channel wood structures will continue to degrade.

The Cumulative Effects of Alternative 1

Under Alternative 1, watershed management in the analysis area would continue to concentrate on reducing erosion introduction and routing into streams, upgrading road stream crossings to provide for aquatic organism passage and stream function, and lowering road densities. Restoration of wood debris in stream channels, along with improving old growth conditions in riparian corridors that are a source of wood debris to channels, would be an additional focus of future watershed management activities. No effect to water quality and aquatic habitat in these watersheds would occur as a result of selection of this alternative.

The trend in human-caused deforestation was at its worst after the intense period of logging in the late 1800s, followed by a period of re-forestation and agricultural and urban development. By 2013, approximately 40% of the drainage area in the Project Area is considered non-forested (urban, cropland, open field, or early successional forest). Loss of wetland/swamp habitat in the project due to drains as part of agricultural/urban development is considered to be relatively minor. Combined, the above types of land conversion can impact the flood hydrograph, increasing the rates of flow delivery and bank erosion, changing channel morphology, and reducing groundwater recharge. As the human population continues to increase within the watershed, the patterns of development will continue to expand, further aggravating these impacts to hydrologic function and aquatic resources.

As no treatment of vegetation would occur under this alternative, watershed condition in the seven sub-basins would not be affected. Impacts to hydrologic function from vegetation removal are expected to occur upstream and downstream of the Project Area, but would be difficult to detect, much less quantify.

The operation of a variety of dams in the Muskegon River drainage would be expected to continue into the future, with impacts to aquatic organism passage most notable at the Croton and Hardy dam facilities. Fish populations in the lower Muskegon River are expected to continue inter-

annual trends of fluctuation as influenced by environmental conditions and forage availability. Non-native aquatic species are expected to continue their presence in the Muskegon River and its tributaries downstream of Croton Dam. Zebra mussels will continue to attach on many of the larger streambed substrates, with negative impacts to native biota, in particular freshwater mussels that are directly impacted by physical attachment (Carman and Goforth 2003).

Lampricide treatments are expected to continue into the future to suppress invasive sea lamprey populations in tributaries of the lower Muskegon River basin. Negative impacts upon non-target juvenile lake sturgeon from the active ingredient TFM (3-trifluoromethyl-4-nitrophenol) would be expected to continue (Boogaard et al 2003, LRBOI 2014, 2013). Potential impacts upon the freshwater mussel community would also be expected to continue from the associated application of the molluscicide Bayluscide, a synergist to TFM.

The Direct and Indirect Effects of Implementing Alternative 2

Under Alternative 2, a total of 3,166 acres of treatment is proposed within the Project Area, the majority of which is located in the Hickory Creek-Rogue River (32%) and Penoyer Creek-Muskegon River (31%) sub-basins (Table 3-19), followed by the Bigelow Creek (22%), Croton Dam Pond-Muskegon River (9%), Handy Creek-Little Muskegon River (3%), Fourmile Creek-Muskegon River (2%), and Tamarack Creek (1%) sub-basins.

Vegetation treatments would create pockets of non-forest cover (i.e. open acres) in each of the 6th code sub-basins that may indirectly affect the flood hydrograph, stream bank integrity, channel geomorphology, and sediment budget. The greatest potential change in non-forest cover would occur in the Penoyer Creek-Muskegon River (3.7%), Bigelow Creek (3.5%) and Hickory Creek-Rogue River (3.0%) sub-basins, followed by the Croton Dam Pond-Muskegon River Hydrologic Unit Code (HUC) (2.4%). The remaining three Sub-basins (Handy Creek-Little Muskegon River, Fourmile Creek-Muskegon River, and Tamarack Creek) would all experience a less than 0.3% increase in open space. For all seven 6th code sub-basins, increases in non-forest cover resulting from implementation of Alternative 2 would not exceed the DFC of 66% described in the Forest Plan. Implementation of State of Michigan water quality Best Management Practices (BMP) and the HMNF's Watershed Management Standards and Guidelines (pages II-18 to II-22), particularly the Streamside Management Zone (SMZ) guideline should help protect aquatic resources from any impacts to habitat from various vegetation treatments.

Alternative 2 would construct 0.9 miles of new road, reconstruct 7.3 miles of existing road, and close 4.0 miles of Level 2 Forest roads, a net loss of 3.1 miles of road and associated impacts to hydrologic function. This net decrease to road density would be beneficial to watershed condition. Given the generally flat topography in the Project Area along with implementation of BMPs during road construction and/or reconstruction, the risk of sediment delivery to streams is low. Replacing and/or improving nine road-stream crossings in the Bigelow Creek drainage with stream simulation structures would improve aquatic organism connectivity and reduce sediment delivery to the channel. Maintenance of existing in-stream fish habitat structures would be designed to improve and stabilize existing structures and reduce the need for future maintenance. Planting of native tree species in the riparian zone would provide a future source of canopy cover, thermal protection, and large wood recruitment to the stream.

Early Successional Forest Cover (Open Area[1]) in the Seven 6th Code Sub-basins of the Project Area - Alternative 2

Table 3-19

6th Code sub-basin	Watershed acres	Existing Open acres (%)	Alternative 2 Open acres created	Alternative 2 Percent Open area
Bigelow Creek	20,210	4,797 (23.7%)	706	27.2
Penoyer Creek-Muskegon River	26,849	8,471 (31.6%)	991	35.2
Croton Dam Pond-Muskegon River	12,358	2,338 (18.9%)	292	21.3
Fourmile Creek-Muskegon River	22,006	9,562 (43.4%)	58	43.7
Hickory Creek-Rogue River	33,682	19,453 (57.8%)	998	60.7
Handy Creek-Little Muskegon River	37,451	13,429 (35.9%)	94	36.1
Tamarack Creek	25,739	13,941 (54.2%)	27	54.3
Total	**178,295**	**71,991 (40.4%)**	**3,166**	**42.2**

[1]*Percent open area is quantified from current HMNF's GIS data.*

Under Alternative 2, backpack spraying and painting of herbicides (glyphosate, triclopyr, imazapic, etc.) are proposed for up to 100 acres within the Project Area to control unwanted vegetation and NNIP in the Project Area. Herbicide treatments would be conducted by State of Michigan certified pesticide applicators and would not occur in or near standing or flowing water to protect water quality and aquatic organisms.

The Cumulative Effects of Alternative 2

Under Alternative 2, watershed management in the analysis area would continue to concentrate on reducing erosion introduction and routing into streams, upgrading road stream crossings to provide for aquatic organism passage and stream function, and lowering road densities. Restoration of wood debris in stream channels, along with improving old growth conditions in riparian corridors that are a source of wood debris to channels, would be an additional focus of future watershed management activities. Beneficial effects to water quality, aquatic habitat, and aquatic biota in these watersheds would occur as a result of selection of this alternative.

The trend in human-caused deforestation was at its worst after the intense period of logging in the late 1800s, followed by a period of re-forestation and agricultural and urban development. By 2013, approximately 40% of the drainage area in the Project Area is considered non-forested (urban, cropland, open field, or early successional forest). Loss of wetland/swamp habitat in the project due to drains as part of agricultural/urban development is considered to be relatively minor. Combined, the above types of land conversion can impact the flood hydrograph, increasing the rates of flow delivery and bank erosion, changing channel morphology, and reducing groundwater recharge. As the human population continues to increase within the watershed, the patterns of

development would continue to expand, further aggravating these impacts to hydrologic function and aquatic resources.

In the sub-basins affected by this alternative, the majority of open space is a result of agriculture or urbanization. Vegetation treatments proposed under this alternative that most completely remove vegetation (clear-cutting, barrens creation) create open space with the greatest probability of impact to watershed condition. These types of vegetative conversion are a relatively minor spatial component of the proposed action and do not exceed the DFC in the Forest Plan. Similar impacts to hydrologic function are expected to occur upstream and downstream of the Project Area, but would be difficult to detect, much less quantify.

The operation of a variety of dams in the Muskegon River drainage would be expected to continue into the future, with impacts to aquatic organism passage most notable at the Croton and Hardy dam facilities. Fish populations in the lower Muskegon River are expected to continue inter-annual trends of fluctuation as influenced by environmental conditions and forage availability. Non-native aquatic species are expected to continue their presence in the Muskegon River and its tributaries downstream of Croton Dam. Zebra mussels would continue to attach on many of the larger streambed substrates, with negative impacts to native biota, in particular freshwater mussels that are directly impacted by physical attachment (Carman and Goforth 2003).

Lampricide treatments are expected to continue into the future to suppress invasive sea lamprey populations in tributaries of the lower Muskegon River basin. Negative impacts upon non-target juvenile lake sturgeon from the active ingredient TFM (3-trifluoromethyl-4-nitrophenol) would be expected to continue (Boogaard et al 2003, LRBOI 2014, 2013). Potential impacts upon the freshwater mussel community would also be expected to continue from the associated application of the molluscicide Bayluscide, a synergist to TFM.

The Direct and Indirect Effects of Implementing Alternative 3

Under Alternative 3, a total of 2,998 acres of treatment is proposed within the Project Area, the majority of which (33%) is located in both the Hickory Creek-Rogue River and Penoyer Creek-Muskegon River sub-basins (Table 3-20), followed by the Bigelow Creek (18%), Croton Dam Pond-Muskegon River (10%), Handy Creek-Little Muskegon River (3%), Fourmile Creek-Muskegon River (2%), and Tamarack Creek (1%) sub-basins.

Vegetation treatments would create pockets of non-forest cover (i.e. open acres) in each of the 6th code sub-basins, resulting in indirect effects to the flood hydrograph, stream bank integrity, channel geomorphology, and sediment budget. The greatest potential change in non-forest cover would occur in the Penoyer Creek-Muskegon River HUC (3.7%), followed by the Hickory Creek-Rogue River (3.0%), Bigelow Creek (2.7%) , and Croton Dam Pond-Muskegon River Sub-basins (2.4%). The remaining three sub-basins (Handy Creek-Little Muskegon River, Fourmile Creek-Muskegon River, and Tamarack Creek) would all experience a less than 0.3% increase in open space. For all seven 6th code sub-basins, increases in non-forest cover resulting from implementation of Alternative 3 would not exceed the DFC of 66% described in the Forest Plan. Implementation of State of Michigan water quality BMPs and the HMNF's Watershed Management standards and guidelines (pages II-18 to II-22, Forest Plan), particularly the SMZ guideline should help to protect aquatic resources from impacts to habitat from various vegetation treatments.

Early Successional Forest Cover (Open Area[1]) in the Seven 6th Code Sub-basins of the Project Area - Alternative 3
Table 3-20

6th Code HUC	Watershed acres	Existing Open acres (%)	Alternative 2 Open acres created	Alternative 2 Percent Open area
Bigelow Creek	20,210	4,797 (23.7%)	550	26.5
Penoyer Creek-Muskegon River	26,849	8,471 (31.6%)	991	35.2
Croton Dam Pond-Muskegon River	12,358	2,338 (18.9%)	292	21.3
Fourmile Creek-Muskegon River	22,006	9,562 (43.4%)	47	43.7
Hickory Creek-Rogue River	33,682	19,453 (57.8%)	996	60.7
Handy Creek-Little Muskegon River	37,451	13,429 (35.9%)	95	36.1
Tamarack Creek	25,739	13,941 (54.2%)	27	54.3
Total	**178,295**	**71,991 (40.4%)**	**2,998**	**42.1**

[1]*Percent open area is quantified from current HMNF's GIS data.*

Alternative 3 would construct 0.9 miles of new road, reconstruct 7.3 miles of existing road, and close 2.9 miles of Level 2 Forest road, a net loss of 2.0 miles of road and associated impacts to hydrologic function. This net decrease to road density would be beneficial to watershed condition. Given the generally flat topography in the Project Area along with implementation of BMPs during road construction and/or reconstruction, the risk of sediment delivery to streams is low. Replacing and/or improving nine road-stream crossings in the Bigelow Creek drainage with stream simulation structures would improve aquatic organism connectivity and reduce sediment delivery to the channel. Maintenance of existing in-stream fish habitat structures would be designed to improve and stabilize existing structures and reduce the need for future maintenance. Planting of native tree species in the riparian zone would provide a future source of canopy cover, thermal protection, and large wood recruitment to the stream.

Under Alternative 3, backpack spraying and painting of herbicides (glyphosate, triclopyr, and imazapic, etc.) is proposed for up to 100 acres within the Project Area to control unwanted vegetation and NNIP. Herbicide treatments would be conducted by State of Michigan certified pesticide applicators and would not occur in or near standing or flowing water to protect water quality and aquatic organisms.

The Cumulative Effects of Alternative 3

Watershed management in these areas would continue to concentrate on reducing erosion introduction and routing into streams, upgrading road stream crossings in Bigelow Creek to provide for aquatic organism passage and stream function, lowering road densities, maintaining/restoring riparian buffer zones, and restoring stream and riparian habitat. These types of projects should lead to improved water quality and aquatic habitat.

The trend in human-caused deforestation was at its worst after the intense period of logging the late 1800s, followed by a period of re-forestation and agricultural and urban development. By 2013, approximately 40% of the drainage area in the Project Area is considered non-forested (cropland, open field, or early successional forest). Loss of wetland/swamp habitat in the project due to drains as part of agricultural/urban development is considered to be relatively minor. Combined, the above types of land conversion can impact the flood hydrograph, increasing the rates of flow delivery and bank erosion, changing channel morphology, and reducing groundwater recharge. As the human population continues to increase within the watershed, the patterns of development would continue to expand, further aggravating these impacts to hydrologic function and aquatic resources.

Vegetation treatments proposed under this alternative would further increase open space within the affected sub-basins, and while relatively minor this conversion is a concern in the respective watersheds. The creation of additional non-forest area within this basin would further exasperate impacts to the flood hydrograph and other aquatic resources, but do not exceed the DFC in the Forest Plan. Similar impacts to hydrologic function likely continue upstream and downstream of the Project Area and may impact aquatic resources beyond the affected area, but these impacts are difficult to monitor, much less quantify.

The operation of a variety of dams in the Muskegon River drainage would be expected to continue into the future, with impacts to aquatic organism passage most notable at the Croton and Hardy dam facilities. Fish populations in the lower Muskegon River are expected to continue inter-annual trends of fluctuation as influenced by environmental conditions and forage availability. Non-native aquatic species are expected to continue their presence in the Muskegon River downstream of Croton Dam. Zebra mussels would continue to attach on many of the larger streambed substrates, with negative impacts to native biota, in particular freshwater mussels that are directly impacted by physical attachment (Carman and Goforth 2003).

Lampricide treatments are expected to continue into the future to suppress invasive sea lamprey populations in the lower Muskegon River basin. Negative impacts upon non-target juvenile lake sturgeon from the active ingredient TFM (3-trifluoromethyl-4-nitrophenol) would be expected to continue (Boogaard et al 2003, LRBOI 2014, 2013). Potential impacts upon the freshwater mussel community would also be expected to continue from the associated application of the molluscicide Bayluscide, a synergist to TFM. NNIP would continue to be chemically treated in the Project Area.

Aquatic Management Indicator Species

There are two management indicator species (MIS) identified in the Forest Plan, brook trout and mottled sculpin. Recent survey data from within the Project Area is organized for brook trout and sculpin in Table 3-21.

Descriptive Survey Data Describing Densities of MIS Brook Trout and Sculpin[1] from HMNF Fisheries Files

Table 3-21

Species	Reach Length (feet)	Brook trout		Sculpin	
		Number fish per 1000 ft	Size range	Number fish per 1000 ft	Size range
Bigelow Creek Section 16 (Aug 2003)	1000	23	5-9 inches	Present	No Data
Bigelow Creek Section 33 (Aug 2003)	1000	3	5-9 inches	Present	No Data

[1]*Mottled sculpin and slimy sculpin are combined due to the difficulty of taxonomic identification in the field.*

Aquatic Management Indicator Species

Table 3-22

MIS Species	Habitat	Status	Alt. 1	Alt. 2	Alt. 3
Brook trout (*Salvelinus fontinalis*)	Cold, spring fed streams	Brook trout are common in the Project Area.	No change	Possible negative effects from forest removal upon watershed function, positive effects from road-stream crossing improvements. Cumulatively, these effects are not likely to impact the population	Possible negative effects from forest removal upon watershed function, positive effects from road-stream crossing improvements. Cumulatively, these effects are not likely to impact the population
Mottled sculpin (*Cottus bairdii*)	Cold, spring fed streams	Sculpin are present in the Project Area.	No change	Possible negative effects from forest removal upon watershed function, positive effects from road-stream crossing improvements. Cumulatively, these effects are not likely to impact the population	Possible negative effects from forest removal upon watershed function, positive effects from road-stream crossing improvements. Cumulatively, these effects are not likely to impact the population

Past surveys indicate that brook trout are present at variable densities in Bigelow Creek, with greater densities in the headwater segments (Section 33) where brown trout and rainbow trout densities are lower, along with competition for resources and rates of predation. Sculpin were identified as present in each survey segment but were not measured for length or enumerated. In a study evaluating the probability of brook trout extirpation, Thieling (2006) identified a road density threshold of 1.8-2.0 mi/mi^2 for predicting extirpation at the watershed scale. Thieling's criteria suggest that road/trail densities in the Project Area are high enough to cause concern for brook trout populations in the Project Area. It should be noted that Thieling's criteria were developed for a wide variety of watershed types; given the relatively low relief and the natural groundwater hydrology of the Project Area, brook trout populations may not be at as high a risk of extirpation. Thieling also found that when agricultural land cover (a subset of open space) is in the 12-19% range or higher, brook trout populations may be affected. While data specifically describing agricultural land cover is not available in the HMNF's GIS database and precludes an equivalent analysis, Thieling's recommendation reflects how open space can impact brook trout

and potentially other aquatic species and is worth considering. This information is in agreement with a predicted 19% decrease in the brook trout population in Bigelow Creek by 2100 (Steen et al 2010) as a result of expected loss of forest cover. When climate change is included in this model, Steen et al (2010) also predict a considerably greater reduction (up to 90%) in the Bigelow Creek brook trout population resulting from expected increases in water temperature. An evaluation of the effects of implementing the proposed activities of Alternative 2 and of Alternative 3 are presented in Table 3-22.

Herbaceous Vegetation

Existing Condition and Resource-Specific Information

Oak-Pine Barrens and Dry Sand Prairie State Imperiled Communities

The Bigelow-Newaygo Project Area is located in a portion of Newaygo County that has remnant habitat for two natural communities: oak-pine barrens and dry sand prairie that are ranked as S2, State Imperiled habitat by the MNFI (2009). Historically, pine, oak-pine, and oak barrens constituted approximately 10% or 60,000 acres of the MNF portion of the HMNF. Currently, there are approximately 11,000 acres that are structurally similar to barrens conditions (USDA 2005b). Oak-pine barrens are relatively open lands with some trees scattered within, forming a mosaic of openings and clusters of partly shaded areas with canopy closures ranging from 5-60%. The oak-pine barrens were historically found on a variety of landforms on droughty, infertile sand, or loamy sands in Newaygo County.

Prairie also existed on the HMNF as a land type termed dry sand prairie. Dry sand prairie habitat, defined here as Sparta Sand soil type, have true prairie soils distinguished by a dark brown sandy A soil horizon of at least 1 foot, with a yellowish-brown sandy subsoil. These soils are principally loamy sand, strongly acid, and have poor water retention (USDA 2005b). Unplowed remnants of this soil type are often found on slopes. Dry sand prairies occurred on the MNF in Muskegon, Newaygo, and Montcalm Counties with Newaygo County having the largest acreage.

Almost one quarter of all dry sand prairie soil has been so severely eroded that it is no longer considered a prairie soil (USDA 2005b). The total amount of potential prairie habitat that remains in the Counties listed above is 6,795 acres. Of those acres, approximately 3,892 acres are currently in private ownership, and 2,903 acres are under Federal management. A large percentage (82% or 1,894 acres) of good quality prairie soil areas that are currently under Forest management are now pine plantations (USDA 2005b).

A good description of both of these remnant natural communities in Newaygo County and in the Bigelow-Newaygo Project Area can be found in the publications of Kim Chapman (Chapman and Crispin 1984, Chapman et al 1995, Chapman and Brewer 2008) and in the "*Conservation Assessment for Pine Barrens, Oak-Pine Barrens and Oak Barrens*" by Glen Vande Water (2004). Vande Water notes that typically the oak-pine barrens graded into prairie on one side and forest on the other. Chapman and others, such as Leach and Givnish (1999), note that these relatively open landscapes were the easiest land types for western expansion settlement and that these habitats began disappearing almost before the natural communities could be studied or described; so, early descriptions may have been influenced by changes which had already occurred to these land types. Fire was a major disturbance factor influencing the creation and maintenance of these barrens/savanna/prairie ecosystems. Fire frequency in these ecosystems typically ranged from 0-

38 year intervals (USDA 2005b), with the most open areas likely burning in successive years (USDA 2005b, Chapman and Brewer 2008). However, droughty conditions may also play a large factor in the formation and maintenance of barren/savanna habitats. Barrens/savannas, also called oak openings, are a plant community where woody and herbaceous vegetation co-exist in more equal amounts than in forest or grassland (Chapman and Brewer 2008). The dry sand prairie differs from barrens/savannas due to an absence of trees. For simplicity, this section of the Bigelow-Newaygo Project analysis will group the varied types of barren and savanna under the term savanna, and the dry sand prairie will be referred to as prairie.

In an unaltered condition, Michigan savanna and prairie support a diverse flora including numerous species that are characteristic of dry prairies. A number of plant and animal species characteristic of savanna ecosystems were reduced in frequency of occurrence and density once wildfires no longer occurred in Michigan as they had in the past and these communities became closed canopy forests (Vande Water 2004). The majority of historic sites have been destroyed through land conversion or are in a degraded state as a result of plant succession and infrequent fires (Chapman et al 1995). Remaining remnants continue to be threatened by tree encroachment, although this process is typically slower on sandy droughty soils versus rich soils. The development of dense forest canopy results in increased fuel loads. Should fire return to the system, the intensity is often great enough to kill the canopy trees, promote dense sprouting of trees and result in a reduction in open areas. Under natural conditions, frequent low intensity fires rarely killed the canopy trees and maintained an open understory. Tester's (1989) study of the effects of fire frequency on oak savanna at Cedar Creek in east-central Minnesota indicated that frequent burning leads to an increase in true prairie species and a decrease in forest species (Vander Water 2004).

Even in areas where structural characteristics may be similar to savanna conditions, species composition on these acres is highly variable and is often not reflective of native floral conditions. NNIP such as spotted knapweed (*Centaurea stoebe*) and common St. John's-wort (*Hypericum perforatum*) are common components of many of the present day flora. Persistent herbaceous species such as leafy spurge (*Euphorbia esula*), Canada thistle (*Cirsium arvense*), yellow sweet clover (*Melilotus officinalis*), and smooth brome (*Bromus inermis*) are difficult to eradicate and pose a serious problem for barrens restoration (Vande Water 2004). Native savanna flora is generally found as either a small component of the overall flora in open areas, or in small remnant patches within openings. Pennsylvania sedge (*Carex pensylvanica*) often dominates the herbaceous layer and is a barrier to establishment of more diverse floral composition. In the absence of fire, thick mats of Pennsylvania sedge establish, creating a monotypic thick turf carpet that is difficult to eliminate even once fire is reintroduced to the ecosystem (Vande Water 2004). To restore savannas to the Midwestern landscape, restoration efforts frequently target encroached remnants by first mechanically removing encroaching woody vegetation and later re-establishing an understory fire regime (Brudvig and Asbjornsen 2009, Packard 1997). Successful restoration depends upon a careful assessment of existing vegetation in a remnant and a careful adaptive management approach to analyzing the results of each step-wise progressive restoration action applied (Packard 1997).

Of the remnant prairies in Newaygo County, many are second growth prairies following plowing (Chapman and Crispin 1984). Chapman observed that unplowed prairie remnants were characterized by high frequency and cover of the prairie warm season grasses big bluestem (*Andropogon gerardii*) and little bluestem (*Schizachyrium scoparium*) whereas disturbed prairie sites (usually plowed) contained more extensive cover of Pennsylvania sedge and dewberry

(*Rubus flagellaris*), weedy species, and indigenous sand affiliated species coastal jointweed (*Polygonella articulata*), arrowfeather threeawn (*Aristida purpurascens*), and lichens (*Cladonia* spp.). Chapman's work included analysis of prairie/savanna habitat in the Bigelow-Newaygo Project Area, including a list of plants indicative of remnant habitat, and is directly applicable to this analysis. For this project analysis, a list of indicator plants from Chapman (1984) and Herman et al (2001) was compiled for each stand that is either currently in an open condition or has been proposed to have prairie, savanna or opening restoration work conducted in this project. The stand list of indicator species is filed in the Planning Record as the *Bigelow-Newaygo Botany Matrix*.

Swink and Wilhelm (1994) developed a tool to assess the floral quality of remnant savanna/prairie and open woodland landscapes in Illinois. Their Floristic Quality Assessment (FQA) can be used to distinguish high quality remnant plant populations from medium to low quality remnants. We combined the FQA of Swink and Wilhelm with the list of Michigan prairie indicator plants to differentiate high, medium and low quality remnant prairie and savanna lands within the Bigelow-Newaygo Project Area.

The FQA technique of Swink and Wilhelm relies upon a Coefficient of Conservatism (C) that is determined for each native plant in the State. The State of Michigan developed a list of Coefficients of Conservatism (Herman et al 2001) for each Michigan native plant, using a scale of 0-10 "*that represents an estimated probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be pre-European settlement condition*." A plant with a low coefficient, or "C", can be found almost anywhere and has little affinity to a particular habitat type. A plant with a high "C" value is strongly affiliated with a historic remnant landscape and is indicative of a high quality remnant. Use of the FQA can either look at the mean C value for a stand or area under analysis or can use the Floristic Quality Index (FQI) which is calculated by summing the "C"s of an inventory of plants and dividing by the total number of plant taxa (*n*), yielding an average or the mean coefficient of conservatism. The "C" mean coefficient of conservatism is then multiplied by the square root of the total number of plants (*n*) to yield the FQI. The square root of *n* is used as a multiplier to transform the mean coefficient of conservatism and allow for better comparison of the FQI between large sites with a high number of species and small sites with fewer species. Sites with the same mean "C" may have different FQIs, and sites with the same FQI may have different mean "C"s (Herman et al 2001). When comparing similar types of habitats, such as one savanna remnant to another, the authors note that it may be more useful to use mean "C", rather than the FQI.

For the Bigelow-Newaygo Project, both the number of indicator plants for prairie or savanna habitat and the mean "C" value were used for analysis. A mean "C" value greater than or equal to 4 indicates that the stand is a high quality, intact, remnant plant community comparable to pre-settlement vegetation (Packard and Ross 1997). A mean "C" value between 0-2 is considered of low remnant quality. The most difficult areas to assess for ease of restoration, as described by Packard and Ross, are the sites with a mean "C" between 2 and 4 which indicates a medium quality of remnant habitat is present.

Because of the broad range for the medium quality remnant (mean "C" between 2 and 4), the range was further divided with a mean "C" of 3.5 selected as the boundary for a medium-high likelihood of restoration success. Stands with a mean "C" value of 4 or greater should have lighter restoration activities so as to not negatively impact the high quality habitat already present. Packard and Ross describe prairie/restoration as a restoration triage: those with mean "C" values

greater than 4 need the benefit of best expertise available with initial restoration efforts focused on invasive plant control, protection of the most conservative biota, and, if prairie or oak, burning.

The combination of the presence of multiple indicator species, number of species with high coefficients of conservatism, and stands with a mean "C" value greater than or equal to 3.5, indicates, that in this Project Area, the area/stand has remnants of habitat very likely to be successfully managed as or restored to high quality habitat. Restoring or maintaining these areas through prescribed fire, opening maintenance, canopy thinning or removal, and invasive plant treatment would maintain habitat for sensitive plant species as well as the floristic diversity and integrity of the plant community.

Stands identified for potential restoration to savanna/prairie conditions are primarily stands that are currently openings that have woody encroachment or are now typed as forested stands. Of the forested stands most conversion would be from oak/mixed oak stands with lessor amounts being from pine stands. Original prairie/savanna stands which were converted to pine plantations may be more difficult to restore to savanna due to pine needle accumulation and greater acidification of the soil and may require actions to raise soil pH. In addition, if a site has been forested for too long, it may not be possible to restore the site to a savanna/prairie without supplementation of native seed. Seedbank storage of viable savanna/prairie seed may be too degraded to naturally rebound by just removing the timber and reintroducing fire into the site (Ralston and Cook 2013).

In the Bigelow-Newaygo Project, the number of indicator plants for prairie or savanna and the mean "C" were determined for the compartment stands where prairie or savanna restoration or maintenance has been proposed in either Alternatives 2 or 3. The average of the mean "C" value for these stands is 3.54, which is slightly higher than the 3.5 mean "C" marker indicating likely successful management or restoration of the proposed stands to savanna or prairie habitat. Of the 89 stands where savanna or prairie would be restored or managed, 24 stands have a mean "C" greater than or equal to 4, and 6 of these 24 stands have a mean "C" greater than or equal to 4.5. The average number of indicator plant species in each of these stands is 5.34, with 9 stands having 10 or more high quality indicator plants per stand. These results can be found in the tables found in the *Bigelow-Newaygo Botany Matrix* in the Planning Record.

Savanna Karner Blue Butterfly Plant Species

The herbaceous layer is a critical element of savanna ecosystems, especially in providing nectar and food support for the insect community, including the endangered Karner Blue Butterfly (KBB). Recent botanical surveys of stands proposed for savanna restoration in the Bigelow-Newaygo Project were analyzed for the presence of savanna plants, the presence or absence of lupine, and the number of 1st and 2nd flight nectar plant species for KBB (two different flight populations within the summer season).

Vegetation survey results indicate most stands identified for potential savanna restoration in this Project have some savanna remnant nectar plants present; however, they may not persist in the density needed to provide sufficient food for the KBB and they may not produce nectar throughout the 2 population flight periods in a summer. Plant species density was not uniformly sampled during botanical surveys. For each occupied KBB stand, a minimum of four species of nectar plants in each flight season is needed to support KBB, and lupine (*Lupinus perennis*) must be present. Efforts need also be made to develop a greater abundance and not just presence of these nectar species, once the minimum number of species threshold exists. High quality habitat would

include lupine and eight or more nectar species in each flight season for each KBB occupied stand. First flight nectar species present included: bastard toadflax (*Comandra umbellata*), birdsfoot violet (*Viola pedata*), Carolina rose (*Rosa carolina*), common cinquefoil (*Potentilla simplex*), dewberry, frostweed (*Helianthemum canadense*), hawkweed (*Hieracium* spp.), ragwort (*Senecio* spp.), lupine, wild strawberry (*Fragaria virginiana*), flowering spurge (*Euphorbia corollata*), erigeron (*Erigeron* spp.), bluet (*Houstonia longifolia*), dwarf dandelion (*Krigia virginica*), hoary puccoon (*Lithospermum canescens*), yarrow (*Achillea ageratifolia*), and lousewort (*Pedicularis* spp.). Second flight nectar species present included: black-eyed Susan (*Rudbeckia hirta*), blue toadflax (*Nuttallanthus canadensis*), butterfly milkweed (*Asclepias tuberosa*), blazing star (*Liatris* spp.), daisy fleabane (*Erigeron annuus*), dewberry, flowering spurge, goat's rue (*Galega officinalis*), hairy bush clover (*Lespedeza hirta*), harebell (*Campanula rotundifolia*), hoary puccoon, horsemint (*Monarda punctata*), lanceleaf coreopsis (*Coreopsis lanceolata*), bluet, hawkweed, racemed milkwort (*Polygala polygama*), rough blazing star (*Liatris aspera*), sweet everlasting (*Pseudognaphalium obtusifolium*), dogbane (*Apocynum androsaemifolium*), spirea (*Spiraea* spp.), bedstraw (*Galium* spp.), common milkweed (*Asclepias syriaca*), New Jersey tea (*Ceanothus americanus*), wild bergamot (*Monarda fistulosa*), woodland sunflower (*Helianthus divaricatus*), yarrow, thimbleweed (*Anemone* spp.), evening primrose (*Oenothera biennis*), aster (*Symphyotrichum* spp.), and goldenrod (*Solidago* spp.).

Since a diversity of nectar plants is present in many stands, but abundance of nectar plants may be below a level needed for good pollinator habitat, it is important to conserve the present seed bank and existing native plant populations while encouraging a greater density of flowering nectar species. Table 3-23 indicates the management strategy of addressing supplementation of native nectar plants in the Project Area for Alternatives 2 and 3.

Summary of Strategy for Seeding of Nectar Plants for Karner Blue Butterfly Targeted Stands

Table 3-23

Current Nectar Species Composition Category	No lupine	Lupine present, but <4 nectar species per acre in both flight seasons	Lupine present, 4-7 nectar species present per acre in both flight seasons	Lupine present, 8 or more nectar species present per acre in both flight seasons
Treatment Recommendation	Plant lupine	Plant to increase nectar species presence, and treat (burn, fence) to increase population density of desired plants.	Plant to increase nectar species presence, and treat to increase population density of desired plants. Plant either by overseeding after burn or scarify/ disc areas of Pennsylvania sedge and seed or plant plugs of nectar plants.	Monitor and treat to increase population density of nectar plants. Scarify/disc areas of Pennsylvania sedge and seed or plant plugs of nectar plants to increase abundance of nectar plants without disturbing current nectar populations.

If savanna restoration occurs as proposed in Alternatives 2 and 3, then as much as is possible, southern Michigan native genotype plant materials would be used for savanna restoration in accordance with the Forest Service Native Plant Materials Policy (USDA 2012a). The Forest Service Manual Section 2070.3 also states that the Forest Service is to ensure genetically

appropriate native plant materials are given primary consideration in re-vegetation, restoration, and rehabilitation of NFS lands, and that genetically appropriate plants are those genetically diverse to respond and adapt to changing climates and environment conditions; unlikely to cause genetic contamination and undermine local adaptations…and are likely to maintain critical connections with pollinators. As noted by Tallamy (2007) and others, local genotype plant materials may be an important factor in sustaining local insect populations. When or if Michigan sourced seed is not available in a sufficient supply, the Michigan sourced seed would be augmented with Wisconsin sourced seed as the next best selection source, followed by other western Great Lakes states, if Wisconsin supplies are also exhausted.

Threatened/Endangered/Regional Forester Sensitive Plant Species

No federally Threatened or Endangered plant species are found or are expected to occur within the Project Area. Sensitive plants include other plant species at risk. RFSS are species listed by the Regional Forester that have a national or State ranking of 1-3, have potential habitat or populations on the HMNF, and are shown by risk evaluation to be at risk.

Field surveys were conducted in the Bigelow-Newaygo Project Area during the 2011 through 2014 field seasons, with several stands surveyed in 2008 and 2006 for other projects. Survey results, which include habitat descriptions and observed species lists, are filed with the District Botanist at the BWC Ranger Station.

A Biological Assessment and Evaluation (BA/BE) was prepared for the Bigelow-Newaygo Project (see Planning Record). The BE evaluated the effects of this project under all alternatives on federally listed or proposed plant species, designated critical habitat, and RFSS that may inhabit the Project Area.

Because no federally listed plant species or designated critical habitat occurs in the Project Area, only RFSS were analyzed in the BE if the species had the potential to occur within or near the Project Area based upon suitable habitat or known occurrences. Sources of data for occurrences were the MNFI, Forest Service's Natural Resource Information System Threatened, Endangered, and Sensitive Plant species database, the Online Atlas of Michigan Plants (*http://herbarium.lsa.umich.edu/website/michflora/*), and Project Area surveys.

Table 3-24 lists the RFSS plants found during surveys of the Project Area and species occurrences recorded in the above databases.

Several other rare plants or species of concern have been found within or close to the Project Area (MNFI 2014). These species include: black-fruited spikerush (*Eleocharis melanocarpa*), a State Species of Special Concern (SC); bald-rush (*Rhynchospora scirpoides*), a State Threatened species (ST) and RFSS; tall beak-rush (*Rhynchospora macrostachya*), an SC; whorled mountainmint (*Pycnanthemum verticillatum*), an SC and RFSS; meadow beauty (*Rhexia virginica*), an ST and RFSS; strict blue-eyed grass (*Sisyrinchium strictum*), an SC and RFSS; prairie golden alexander (*Zizia aptera*), an ST; and upland boneset (*Eupatorium sessilifolium*), an ST and RFSS.

In addition to the sensitive plants that have been found within or close to the Project Area, there are habitats present that have the potential to support other sensitive species. Appendix C lists RFSS plants for the HMNF for which potential habitat(s) exist in the Project Area.

RFSS Identified in the Project Area

Table 3-24

RFSS Plant Species	Compartment	Stand(s)
Oneida grape fern (*Botrychium oneidense*)	517	7
"	522	20
"	578	9
Ternate grape fern (*Botrychium rugulosum*)	519	36-39
Prairie smoke (*Geum triflorum*)	517	29
"	519	26,38
"	573	5,13
Furrowed flax (*Linum sulcatum*)	573	1,13
Western silvery aster (*Symphyotrichum sericeum)*	517	11
"	573	5,13

Non-Native Invasive Plant Species

The HMNF has identified certain plants as NNIP. Each NNIP has a priority ranking for treatment. In addition, some areas within the HMNF are ranked as higher priority lands and may have treatment of lesser ranked NNIP to maintain the quality or character of that management unit. For example, habitat for a federally Threatened or Endangered species that has NNIP that are ranked as 4 for treatment would be treated for invasive control so as to protect the native plants that are maintaining the habitat for the Federally listed species.

The management of NNIP is important because they have the capacity to transform or dominate native plant communities, and easily become established in areas that are frequently or severely disturbed, such as road clearings, landing sites, and skid trails. NNIP also impact insects and wildlife. Non-native plants fail to support the insect diversity and biomass that native plants do. Most insects cannot or will not eat non-native plants. About 90% of herbivorous insects are specialists and will only feed on a few plant lineages. The remaining 10% of herbivorous insects are able to feed on multiple species and may adapt to a non-native plant if it is similar enough to their host plants. Unfortunately, many non-native plants are not closely related to any species in North America, making it unlikely that native insects will be able to use those species anytime soon (Tallamy 2007). Comparisons of Lepidoptera and sawfly caterpillar use of native versus non-native woody plants indicate that the native plants support 35 times more insect biomass than non-native woody plants. Since Lepidoptera and sawfly caterpillars are the largest component in the diets of insectivorous birds, this decline in caterpillar biomass could impact these species

(Tallamy 2007). As NNIP displace native plants, fewer insects would be available to other members of the food web, causing a ripple effect throughout the animal community. Therefore, Alternatives 2 and 3 would have a positive effect on maintenance of native plant foods for insects, and the wildlife food chain.

Twenty-three NNIP found in the Project Area have been identified for herbicide or mechanical treatment within stands where treatment would likely result in an increased spread of the NNIP due to the treatment activity (Table 3-25).

Non-native Invasive Plant Control Recommendations
Table 3-25

NNIP	Forest Rank[1]	Forest Direction	# of Herbicide Locations[2]	# of Mechanical Locations[3]	Recommended Action
Autumn olive (*Elaeagnus umbellate*)	4	control	12	12	mechanical herbicide
Black locust (*Robinia pseudoacacia*)	3	control eradicate	5	5	mechanical herbicide
Bull thistle (*Cirsium vulgare*)	4	control eradicate		2	mechanical
Burning bush (*Euonymus alatus*)	2	eradicate		1	mechanical
Canada thistle (*Cirsium arvense*)	4	control eradicate	6		herbicide
Common Burdock (*Arctium minus*)	3	control eradicate	2		herbicide
Crown vetch (*Securigera varia*)	2	eradicate	6		herbicide
Cypress spurge (*Euphorbia cyparissias*)	2	eradicate	18		herbicide
Dames rocket (*Hesperis matronalis*)	1	eradicate		1	mechanical
Field bindweed (*Convolvulus arvensis)*	5	control	1		herbicide
Garlic mustard (*Alliaria petiolata*)	2	eradicate	5		mechanical herbicide
Glossy buckthorn (*Frangula alnus*)	2	eradicate		1	mechanical
Honeysuckle (*Lonicera* spp.)	3	control	44	44	mechanical herbicide
Barberry (*Berberis* spp.)	2	eradicate		2	mechanical

NNIP	Forest Rank[1]	Forest Direction	# of Herbicide Locations[2]	# of Mechanical Locations[3]	Recommended Action
Leafy spurge (*Euphorbia esula*)	3	control eradicate	3		herbicide
Lombardy poplar (*Populus nigra*)	3	control eradicate	1	1	herbicide
Mullein (*Verbascum thapsus*)	3	control		28	mechanical
Multiflora rose (*Rosa multiflora*)	2	eradicate	4		herbicide
Norway maple (*Acer platanoides*)	3	control eradicate		2	mechanical
Oriental bittersweet (*Celastrus orbiculatus*)	2	eradicate	1		herbicide
Scots pine (*Pinus sylvestris*)	4	eradicate		1	mechanical
Spotted knapweed (*Centaurea stoebe*)	4	control	33		herbicide
Wild garlic (*Allium vineale*)	5	eradicate		2	mechanical
			141	**101**	**Total Estimated**

[1]*Ratings of Forest Priority are levels that determine the need to focus treatment attentions on either controlling or eradicating the NNIP. This rating takes into consideration such factors as current presence on the Forest, potential of spread, and the desired habitat characteristics.*
[2]*It is probable that this number would be larger by the time treatment occurs due to movement and increased infestation.*
[3]*It is probable that this number would be larger by the time treatment occurs due to movement and increased infestation.*

Of these 23 species, 9 species are proposed to be treated through mechanical means such as cutting or pulling out of the ground by hand or weed wrench. This correlates to 39 sites. Thirteen species are proposed to be treated through the use of herbicide at 108 sites. For 4 of these 13 species, herbicide would be applied in combination with mechanical treatment, such as cut stem herbicide application. For those proposed for herbicide treatment, Table 3-26 presents the amount of surface area expected to receive herbicide, the number of acres in which herbicide treatment would occur in, and which herbicides would be used.

In addition to invasive plant treatment, spread of NNIP seed or vegetative fragments can be reduced from management activities by equipment cleaning if either Alternatives 2 or 3 is selected. If mechanical equipment is moved from a stand containing one of these species, then the mechanical equipment for timber harvest needs to be cleaned as specified in the applicable timber harvest contracts. For this project, this would occur in areas where ground disturbing treatments could potentially introduce or increase the spread of these NNIP.

Non-native Invasive Plant Proposed Herbicide Control
Table 3-26

NNIP	Surface Area For Herbicide Application Acres	Expected Treatment Acres	Herbicide
Autumn olive (*Elaeagnus umbellate*)	2	12	glyphosate triclopyr
Black locust (*Robinia pseudoacacia*)	0.1	5	glyphosate triclopyr
Canada thistle (*Cirsium arvense*)	1	6	glyphosate
Common Burdock (*Arctium minus*)	0.1	2	glyphosate
Crown vetch (*Securigera varia*)	0.5	6	glyphosate
Cypress spurge (*Euphorbia cyparissias*)	1	18	glyphosate imazapic
Field bindweed (*Convolvulus arvensis)*	1	1	glyphosate
Garlic mustard (*Alliaria petiolata*)	0.6	5	glyphosate
Honeysuckle (*Lonicera* spp.)	5	44	glyphosate triclopyr
Leafy spurge (*Euphorbia esula*)	0.3	3	glyphosate imazapic
Lombardy poplar (*Populus nigra*)	0.1	1	glyphosate triclopyr
Multiflora rose (*Rosa multiflora*)	0.2	4	glyphosate triclopyr
Oriental bittersweet (*Celastrus orbiculatus*)	0.1	1	glyphosate triclopyr
Spotted knapweed (*Centaurea stoebe*)	5	33	glyphosate
	12	**108**	**Total Estimate**

Herbicides would be applied according to the product label (FSH 2109.14, 52.11); specifications in the Forest Service Manual 2150, *Pesticide Use Management and Coordination*; and Forest Service Handbook 2109.14, *Pesticide Use Management and Coordination Handbook*. Also, compliance with all Federal, State, and local regulations regarding herbicide use would be followed. Herbicide application would be conducted and/or overseen by certified personnel (FSM 2154.2). Monitoring would occur on a daily basis during periods of herbicide application.
The target species for pre-treatment equipment cleaning include: garlic mustard (*Alliaria petiolata*), wild garlic (*Allium vineale*), common burdock (*Arctium minus*), yellow rocket

(*Barbarea vulgaris*), barberry (*Berberis* spp.), hoary alyssum (*Berteroa incana*), smooth brome, oriental bittersweet (*Celastrus orbiculatus*), spotted knapweed, Canada thistle, orchard grass (*Dactylis glomerata*), cypress spurge (*Euphorbia cyparissias*), leafy spurge, glossy buckthorn (*Frangula alnus*), common St. John's-wort, yellow sweet clover, reed canary grass (*Phalaris arundinacea*), multiflora rose (*Rosa multiflora*), purple crown vetch (*Securigera varia*), mullein (*Verbascum thapsus*), and common periwinkle (*Vinca minor*). The list of target NNIP would be expanded in the areas of KBB habitat creation or restoration. The *Bigelow-Newaygo Botany Matrix* includes a summary of equipment cleaning for NNIP by stand and is located in the Planning Record.

In addition, areas that are seeded or planted with native nectar species would need to be monitored for the presence of NNIP for up to 10 years following the seeding or planting. It is expected that hand pulling of weeds in seed plots would effectively eliminate NNIP problems in most cases as long as hand-pulling occurs prior to seed dispersal by the invasive plant species. In cases of seeding failure, stands may need to be retreated and reseeded to eliminate creation of a stand dominated by NNIP.

Area of Analysis

The area of analysis for the direct and indirect effects on the herbaceous vegetation is the NFS lands where treatments would occur, and adjacent NFS and private lands within ¼ mile of treatment sites. This area represents a reasonable distance for plant seed dispersal. The area of analysis for the cumulative effects on all vegetation is the southern and middle portions of the lower peninsula of Michigan. This area has been identified due to the similarities across this region relative to growing conditions, plant species composition, and the impacts related to human activities.

The Direct and Indirect Effects of Implementing Alternatives 1, 2, and 3

For all analyses the assumption is made that all conservation measures would be implemented and all prescribed activities in the selected alternative would be implemented.

Effects on Oak-Pine Barrens and Dry Sand Prairie State Imperiled Communities and KBB Nectar Plant Species

The Bigelow-Newaygo Project Area is a State recognized area of historic significance for remnant prairie and oak-pine barrens, two natural communities that are imperiled in the State. These two communities, in turn, support remnant rare plants and wildlife, including the federally endangered KBB. The Forest Plan recognized the diminishing quality and quantity of these two natural community types and provided direction to manage the Sparta soils series on the MNF as prairies and, in Management Area (MA) 4.4, to create dry prairie habitat on Sparta soils. Under Forest-wide management direction, it is also directed to "*Restore and maintain savannas, prairies, dry grasslands, mesic grasslands, shrub/scrub and oak-pine barrens in areas where they were known to previously occur, to provide for habitat diversity and to meet species viability needs*."

Vegetative Management - Timber Harvest

Under Alternative 1, no treatment would occur. The only disturbance occurring would be that of natural origin such as wildfire, wind throw, or tree mortality due to insects or disease. Oak and oak-pine stands would continue to mature and areas of more open lands would continue to fill in with woody vegetation. For savanna and prairie species that are light dependent, continued maturing of forested lands would most likely result in a decline in residual savanna, prairie and nectar plant species, and associated wildlife assemblages.

Under Alternatives 2 and 3, timber harvesting would occur for several different treatment goals: pine thinning; Scots pine (*Pinus sylvestris*), an NNIP, removal; and, oak/pine cuts for savanna or prairie restoration (discussed in the next section). Prairie, savanna, and KBB nectar plant species require relatively open conditions. While the canopy would decrease in the short-term following timber harvest, open conditions would not persist for any length of time to benefit savanna/nectar plant habitat availability without continued management such as prescribed burning to maintain an open condition. In some forested stands where KBB nectar plants are currently present, they would be expected to increase in the short-term with an increase in the canopy openings. In addition, some KBB nectar plants are non-native plants with an early-successional pioneer strategy. It is likely these species (such as hoary alyssum, hawkweed, spotted knapweed, and common St. John's-wort) would enter into newly opened areas. Studies suggest that openings or corridors within forested stands can support KBB if lupine and other nectar species are present (Kleintjes et al 2003). In areas already populated by KBB, an increase in lupine and nectar plant presence in a heterogeneous habitat setting would provide a close proximity of shade plus lupine/nectar availability, thus enhancing habitat conditions for the KBB.

Savanna Restoration and KBB Nectar Plants

Under Alternative 1, no treatment would occur. The only disturbance occurring would be that of natural origin such as wildfire or wind throw. Plant succession would continue to progress, woody vegetation would continue to dominate the landscape in forested areas, and would continue to encroach upon, and expand within, openings. Biodiversity of fire-dependent savanna herbaceous plants would continue to decrease in semi-open canopy oak forest, as more competitive species (such as Pennsylvania sedge) would continue to increase.

Under Alternatives 2 and 3, treatment activities would occur to reduce woody vegetation and encourage the presence and abundance of savanna and KBB nectar plants. Alternatives 2 and 3 would promote an adaptive management approach to savanna restoration, with each potential treatment action having the results monitored prior to implementation of another treatment action. In some cases, one or two initial treatments could potentially be sufficient to meet objectives, without additional types of treatment being implemented.

Nectar planting of a stand being restored for KBB habitat would be done based upon a stand by stand analysis of the need for nectar plant increases, as described in Table 3-23. Scarification of the soil for nectar seed planting would result in direct impacts to savanna species already present; however, seed planting sites would be located to minimize soil scarification in areas of high quality savanna as noted in the conservation measures.

Herbicide use may be used to reduce re-sprouting of cut woody vegetation. There would be some negative effects on savanna/nectar plants if any herbicide came into contact with adjacent, non-

target vegetation. This is expected to be minimal during stump application due to the nature of specific confined location of herbicide application. There is potential for spot and strip application of herbicide to also injure or kill adjacent or nearby non-target plants. In addition, some aggressive native vegetation such as bracken fern (*Pteridium aquilinum*) or Pennsylvania sedge may be treated in up to 10% of the stand to reduce competition for more desirable nectar plant species. Strip herbicide treatment may also be done in up to 10% of the stand to prepare for nectar planting as noted above. Biologist/botanist identification of herbicide spray locations in the savanna treatment units would minimize the effects of herbicides on savanna/nectar species whose presence is determined to be of importance to meeting project objectives. It is most likely that some adjacent or understory plant mortality would occur in treatments to reduce aggressive native plant species due to spray drift. Triclopyr can also affect non-target plants due to some accumulation in the soil and the related plant uptake through the roots (Newton et al 1990), so some non-target mortality could occur in treatment of woody sprouts, but this is expected to be minimal.

Prescribed burning is a preferred method of treatment for savanna restoration, as it mimics wildfire conditions that were instrumental in maintaining pre-settlement savanna conditions. Prescribed burning, depending upon timing and fire intensity, would result in a reduction of woody plants, release nutrients for herbaceous plant growth, decrease the presence/abundance of non-fire adapted plant species, increase soil exposure to solar warming to favor warm season grass growth, and open up the ground layer for seed germination of savanna species. Effects, overall, would be a positive response for nectar or rare savanna plants, though adaptive management monitoring would be essential to ensure that fire effects are not causing an increase in either bracken fern or Pennsylvania sedge.

Soil scarification would occur following fire or due to mechanical scarification treatments. Soil scarification can result in the appearance of additional species present in the seedbank, and favors opportunistic species. Negative effects would occur for savanna plant community composition when NNIP are stimulated by scarification. Positive effects would occur for native species which are stimulated by the soil exposure, such as lupine and Hill's thistle (*Cirsium hillii*). Scarification by fire would benefit those species adapted to a fire-dependent ecosystem and would encourage an increase in more conservative savanna species such as June grass (*Koeleria macrantha*), lupine, birdsfoot violet, and others. Conservation measures to monitor for NNIP following savanna restoration activities would minimize the inadvertent creation of large areas of NNIP.

Scarification by mechanical means would not provide the same benefit of suppression of non-fire adapted species and encouragement of savanna fire-dependent plants. It would result in a change in plant composition dependent upon successful herbicide application and the subsequent planting/seeding of native species. It would provide a positive benefit in situations where Pennsylvania sedge forms a monotypic mat that precludes the presence of most other plant species. Scarification to break up the root mass of the sedge, followed by herbicide application and subsequent planting of natives would help improve stand biodiversity and increase the presence/abundance of savanna/nectar species. Mechanical scarification in areas that already have a good nectar seedbank would potentially encourage invasive plants and may kill off seed sources of more conservative nectar or savanna species, or species that are not commercially available for re-planting, thus moving the stand away from a diverse herbaceous layer and a variety of nectar species.

The planting of plugs or seeding of native plants to serve as inoculum for stands currently occupied by KBB would result in an increase in either the number of savanna or nectar species present or an increase in abundance of species already present at lower densities. This would provide a positive effect of recruiting additional savanna/nectar species where the species is currently not present. An increase in abundance of species already present would primarily be of benefit for meeting wildlife objectives. To avoid a negative impact on existing nectar species in the stand, plugs would need to be placed outside of areas which already have good nectar species presence or where conservative savanna indicator plant species already occur.

Under Alternatives 2 and 3, southern Michigan genotype seed source plant material would be used to the extent of market availability and funding allow. Studies suggest that genetic variability is such that for some species genotype of forb species, regional variations may affect successful food support for pollinators (Tallamy 2007) and in fact, greater plant genotypic biodiversity has been shown to support greater insect species richness (Crutsinger et al 2006). Restoration using non-local seed may result in genotypes that persist for a long period of time (Gustafson et al 2005), affecting growth form, phenology and competition between local and non-local genotypes, and ultimately, pollinator insect support. Other studies are highlighting the consequences of habitat fragmentation that results in genetic erosion and loss of genetic diversity that allows plant populations to maintain a mutation-drift balance and be able to better adapt to changing environmental conditions (Honnay and Jacquemyn 2007).

Increased open lands favoring herbaceous vegetation would likely result in an increase in deer browsing. Herbivory has a noted effect on reduced nectar presence in the Project Area. The added density of cut woody stems from canopy opening treatment would also likely add to the presence of rabbit and small mammal habitat which would result in additional herbivory pressure on savanna nectar species unless brush/woody debris piles are removed from the Project Area or are chipped. Some herbivory effects would be reduced for areas of native plant plug planting when exclosure fencing is used, which would allow for enhanced development of nectar flowers and seeds for dispersal into other portions of the savanna. Deer grazing pressure can have an additional negative effect by reducing native plant richness while increasing the presence of exotic invasive plants (Seabloom et al 2009).

Prairie Restoration

Under Alternative 1, no treatment would occur. Stands with Sparta sand soils that currently exist as a pine or oak/pine stand would continue to exist as a forested stand. Areas that currently have remnant prairie species present would likely continue to experience loss of high quality prairie species if/when canopy gaps closed. Prairie species present in the seed bank would eventually become non-viable, reducing local genotypic prairie seed in the area and making the site too degraded to naturally rebound by removing the timber and reintroducing fire into the site (Ralston and Cook 2013). Alternative 1 would not follow guidance of the Forest Plan direction to manage Sparta soils as dry prairie.

Under Alternatives 2 and 3, prescribed burns would take place on 186 and 197 acres, respectively. This would move those stands closer to the desired condition of dry sand prairie in areas where canopy light gaps exist. Commercial thinning of red pine stands in Sparta soil stands are proposed for 612 and 657 acres, respectively. Thinning of the canopy would help to create temporary canopy gaps for any remnant prairie species present; however, the effect would be short-lived once

the canopy gaps closed due to residual red pine canopy expansion. Neither activity by itself or in combination would result in quality dry sand prairie restoration.

Opening creation/prairie restoration is proposed for 78 acres of red/white pine forested stands with Sparta sand soils in Alternative 2 and 34 acres in Alternative 3. These acres would undergo timber clearing and broadcast burn. Once vegetation responds to these activities, supplemental seeding of native herbaceous plants may be undertaken if natural rebound does not occur. In addition, 237 acres of current open lands in the Sparta sand soil series would be managed for open lands with prescribed burning, cutting of encroaching shrubs and trees, treatment of NNIP, and supplemental seeding as options for management in Alternatives 2 and 3.

Lastly, 105 acres of stands with Sparta sand soils would be managed as savanna rather than dry sand prairie due to the presence or proximity of KBB in Alternative 2 and on 62 acres in Alternative 3. In both of these alternatives, 25 acres of the proposed savanna creation would occur in already open lands, while the remaining 80 and 37 acres, respectively, would be converted from red pine to savanna. Management of Sparta sand soil acres as savanna would move the stands into the direction of prairie in stands where more trees or shrubs currently exist as many of the savanna plant species are also found in prairies and historically there was a natural gradient between one into the other. Management of proposed savanna creation on already open lands would follow conservation measures to ensure the preservation of high quality prairie plant species.

While Alternatives 2 and 3 would both result in restoration of some of the Sparta sand soil prairie, Alternative 2 has slightly more than double the acres which would be restored and would provide greater positive contribution to restoration of this imperiled natural community and its component plant and animal species.

Reduce Presence and Threat of Select Invasive Species

Under Alternative 1, no treatment would occur. In areas where NNIP exist within or adjacent to current openings, NNIP presence would expand within stands. This would further reduce habitat for savanna, prairie and KBB nectar plant species. This alternative would not follow Forest Service direction to manage for NNIP (Executive Order 13112; Forest Service Manual 2080 and 2081; Forest Service National Strategic Framework for Invasive Species Management (USDA 2013b); Non-native Invasive Species Framework (USDA 2003a); and, the Forest Plan.

In Alternatives 2 and 3, 23 NNIP would be treated manually, mechanically, or with herbicide, as listed in Table 3-26 for up to 108 acres if funding allows full treatment as planned. Emphasis on treatment locations is in areas where openings currently exist or would be created. More NNIP exist within the Project Area than is economically feasible to treat. Emphasis on treatment is toward the highest priority lands in the Project Area, and the most impactful NNIP to the DFC for each stand identified. There would be a positive effect for savanna, prairie, and nectar species due to minimizing the loss of native habitat available for savanna/prairie/nectar plant growth and reducing competition from NNIP.

Under Alternatives 2 and 3, herbaceous NNIP considered a threat to nectar plant establishment or nectar abundance levels necessary for KBB would receive herbicide application. In many of the stands, the NNIP are currently present primarily along trails and roadbeds and are not present within the interior of the stand. In such situations, it would have a positive effect to manage for reduction of the NNIP along the road edge to reduce the risk of spreading NNIP into the interior of

the stand and negatively impacting nectar species. Allelopathic NNIP (such as spotted knapweed) would be targeted where they are present in the interior of the stand. In most cases, it would be possible to limit the herbicide spray activities to a handheld sprayer or a wick application for single stem or small clump application. In a few locations, the herbaceous NNIP may be present to a large enough degree that strip application would occur. In areas where strip application would be necessary, all plants within the strip would be killed. The negative effects of applying herbicides to desirable savanna prairie/nectar species would be short-term for species that are able to be reseeded into the affected strips. Some savanna/prairie species are not easily re-established or are not commercially available. It is possible that there would be some localized negative effect of reducing the presence of some savanna/prairie species due to herbicide application, particularly in the areas receiving strip application. This effect would be mitigated by marking and excluding or providing protective covering to more conservative savanna/prairie/nectar species prior to herbicide application.

Transportation System, ORV Damage

Under Alternative 1 no changes would occur to current conditions, other than those changes not yet implemented from earlier planning decisions such as the Motor Vehicle Use Map (MVUM) road analysis. Roadways would continue to function as a vector for NNIP introduction and as a dispersal corridor. In Alternatives 2 and 3, redundant roads or roads causing resource damage would be closed. In general, closing of roads would result in a reduction of a major vector of NNIP spread. This would be of benefit to savanna/prairie plant species since less native habitat would be lost to invasive plants. There would probably still be some NNIP movement along closed roadways for those plants already established along road corridors.

Off-road vehicle (ORV) use on the HMNF is authorized to occur on managed trails; however, illegal usage occurs on the HMNF and results in destruction of plants and erosion damage to plant habitat. An example of such damage is in compartment 517 stand 41 which is a prairie remnant and a RNA with 15 high quality remnant prairie species present, including the State threated prairie smoke (*Geum triflorum*). Areas exist within the stand with tire tracks and vegetation eroded to a condition of loose sand travel ways. It is difficult to restore vegetation in pure sand soil conditions and these sandy trail ways are an attractive disturbed habitat for increased presence of invasive species, such as spotted knapweed which is noted as the highest rank density occurrence (common) for this stand. Increased open lands created under Alternatives 2 and 3 create a larger acreage of land conditions attractive to this type of illegal usage. Increased MNF staff presence for savanna/prairie restoration activities would likely improve the likelihood of early detection and remedial response to such activities occurring in the area.

In summary, there would be no direct effects to the imperiled savanna/prairie communities or KBB nectar species with implementing Alternative 1 since no actions would occur. The indirect effects, however, of implementing Alternative 1 would result in the continued loss in quality and quantity of the remnant prairie and savanna habitat due to continued lack of fire in the landscape, continued encroachment by NNIP, and continued canopy closure resulting in non-open conditions. The trend of degradation of habitat would continue to reduce viable habitat for component species such as rare plants and nectar species for KBB and other declining pollinator species. This alternative would not implement direction provided by the Forest Plan.

Alternatives 2 and 3 would provide an improvement in protection and restoration of the State imperiled savanna/prairie communities and KBB nectar species through a reduction in tree canopy

cover to increase light flux to the ground level, a reintroduction of fire as a natural stimulant of fire-adapted species and reduction of non-fire-adapted species, control and eradication of NNIP in important habitat areas, and reduction of redundant roads and illegal ORV use resulting in eroded soils. Alternative 2 provides greater dry sand prairie restoration acreage than Alternative 3.

Effects on Non-Native Invasive Plant Species

Vegetative Management - Timber Harvest

Under Alternative 1, no timber treatment would occur. Some new infestations of honeysuckle and autumn olive (*Elaeagnus umbellate*) would most likely occur in openings within wooded stands or at stand edges due to NNIP dispersal by wildlife or other dispersal vectors. Lack of soil disturbances typically associated with timber harvesting activities would limit the opening of the soil to new NNIP infestations in the stand interior (such as spotted knapweed). Continued canopy closure would limit the growth and spread of shade-intolerant invasive species such as autumn olive. Cypress and leafy spurge would continue to spread in forested and non-forested stands as opportunities occur for dispersal from current population locations.

Under Alternatives 2 and 3, timber harvest activities would result in soil disturbances conducive to NNIP establishment and population expansion. Equipment cleaning under these two alternatives is expected to help minimize the spread of NNIP during stand vegetative treatments.

Savanna/Prairie Restoration

Under Alternative 1, no treatments would occur. NNIP, such as autumn olive, garlic mustard, cypress and leafy spurge, and honeysuckle would increase in open areas, reducing the amount of habitat available for native herbaceous species. NNIP would likely spread to additional locations within the Project Area.

Under Alternatives 2 and 3, varied treatments for savanna/prairie restoration would occur in an adaptive management approach. After each treatment action occurred, analysis would be made of resulting conditions to determine if or what type of additional treatments would be needed to provide adequate quality habitat for KBB or for prairie habitats. These treatments could affect NNIP levels when ground disturbance occurs or plant propagules are inadvertently introduced into the stand on equipment. Timber removal would result in soil disturbance that would be conducive to NNIP germination. Hand cutting would have minimal effect on the NNIP present.

Prescribed burning can be used to help reduce invasive plants and encourage the growth of species that are characteristic of healthy ecosystems. Many invasive plants begin growth early in the spring, prior to native plants. This makes prescribed burning during the spring season effective for reducing some invasive species. Fire is most effective over time, gradually increasing the numbers of species that naturally occur in ecosystems, while reducing non-native and native invasive species until a natural balance is achieved (Chicago Wilderness 2003). Precise timing of the fire can reduce specific NNIP. For example, late April to mid-May burning can greatly reduce spotted knapweed seedling survival (MacDonald et al 2007). Plow lines constructed for fire control would result in soil exposure conducive to NNIP germination. Immediate re-seeding of plow lines would help reduce this risk, though the timing of seeding in combination with weather conditions would result in variable success levels of limiting NNIP germination. Prescribed burns would result in an increase in NNIP in situations where soil scarification occurs and weed seed sources are nearby.

Prescribed burns would also result in an increase in some NNIP such as autumn olive and leafy spurge due to a growth stimulation response to fire disturbance, unless cutting or burning of re-sprouts is done annually for up to 5 years.

Seeding treatments would likely result in increases in NNIP presence in the disturbed soil in situations where weather conditions and/or timing of seed planting did not result in complete establishment of native plant species. This would be minimized, however, by limiting herbicide applications and seeding to appropriate weather and seasonal conditions, and by up to 10 years of subsequent weeding of new seedbeds.

Reduce Presence and Threat of Select Invasive Plants

Under Alternative 1, no treatment would occur. NNIP would continue to expand in population size, especially in areas adjacent to roadways and other areas of disturbance. New infestations of NNIP would likely occur. The existing NNIP infestations would go unchecked and the diversity of native plants in the Project Area would decline as NNIP alter or replace native plants, and alter natural ecosystems (Westbrooks 1998). Eventually, the population of an individual NNIP would reach a level at which it would no longer be as feasible to eliminate it from the Project Area. Lack of prescribed fire would allow for the continued domination of more competitive species, as those species which are fire-dependent begin or continue to drop out of the habitat.

Under Alternatives 2 and 3, autumn olive, cypress and leafy spurge, honeysuckle, common burdock, Lombardy poplar (*Populus nigra*), black locust (*Robinia pseudoacacia*), oriental bittersweet, purple crown vetch, garlic mustard, multiflora rose, spotted knapweed, and Canada thistle would be treated with herbicide to reduce population levels in selected stands. Barberry, dames rocket (*Hesperis matronalis*), bull thistle (*Cirsium vulgare*), wild garlic, Norway maple (*Acer platanoides*), Scots pine, burning bush (*Euonymus alatus*), mullein, and glossy buckthorn would be reduced or eliminated using mechanical methods of digging or hand pulling. If mechanical methods are ineffective, then future NEPA may be completed to allow for additional herbicide treatment of some of the above mechanically treated NNIP. The effect of NNIP treatment would be positive for restoring native plant habitat and minimizing the loss of native habitat due to invasive cypress and leafy spurge population expansion. There would still be the possibility of the species proliferating in other portions of the Project Area that were not evaluated for treatment. There would also be a possibility of these species becoming reintroduced into the treatment stands at a future date due to nearby NNIP populations. Autumn olive would be treated in stands which are to be managed to maintain open conditions. This treatment would prevent a decrease in the desired open conditions, and, in the case of autumn olive, would prevent soil chemistry changes (nitrogen fixation) which occur with autumn olive presence that subsequently alter habitat conditions for native plant species. Barberry, glossy buckthorn, purple crown vetch, oriental bittersweet, burning bush, cypress spurge, dame's rocket, honeysuckle, multiflora rose, and garlic mustard are high risk species for the HMNF. These species would be treated for eradication, helping to preserve future savanna/prairie/KBB habitat from invasive impacts. Canada thistle would be treated where determined to be causing a risk to savanna/prairie/KBB habitat. Newly discovered NNIP on the BWC District, including glossy buckthorn, burning bush, and oriental bittersweet, would be treated to bring the BWC District occurrence back to a non-present status.

Additional NNIP treatment would occur in stands being managed for nectar plant species to increase KBB habitat. Herbaceous NNIP considered a threat to nectar plant establishment or

nectar abundance levels necessary to support KBB would receive herbicide application. In many of the treatment stands, NNIP are currently present primarily along trails and roadbeds and are not present within the interior of the stand. In such situations, it would have a positive effect to manage for the reduction of NNIP along the road edge to reduce risk for NNIP seed spread into the stand interior. Allelopathic species (such as spotted knapweed) would be targeted for population suppression in stand interiors in a limited number of stands. In most cases, herbicide application would occur to single stems. In a few locations, the herbaceous NNIP may be present in large enough populations to warrant strip application of herbicide. This would be followed by native plant/nectar plant seeding. In areas where strip application of herbicide occurs, all plants within the strip would be killed. There is a possibility of an increase in NNIP presence if the re-seeding of native plant species results in less than 100% cover during re-vegetation and/or if the seedbank contains viable NNIP seeds. This would be minimized by the weeding of all seedbeds for up to 10 years following seeding.

Overall, the treatments for Alternatives 2 or 3 would result in further NNIP population suppression in Project Area openings and would prevent newly discovered NNIP such as glossy buckthorn, burning bush, and oriental bittersweet from becoming firmly established on the Forest and spreading to nearby lands.

Transportation System, ORV Damage

Under Alternative 1, no treatment would occur though roads identified for closure under prior projects would continue to be closed as identified in those road management decisions. Otherwise, the existing Forest road system would remain in place, and the threat of new introductions and spread of existing NNIP would be sustained or increase with travel and visitor use. NNIP would likely germinate in soils exposed due to ORV damage. The consequence of unchecked NNIP plant spread would be a reduction of habitat for native vegetation and those species that rely upon specific native plant species such as the KBB.

Road closure would occur under Alternatives 2 and 3 which would reduce the spread of NNIP through road maintenance activities such as plowing and grading, and would reduce the amount of vehicle disturbance that creates optimal conditions for NNIP germination. It is expected that some spread of NNIP would still occur for populations already established along road corridors.

Determination Table by Habitat Type for RFSS Plants
Table 3-27

RFSS Habitat	Alternative 1	Alternative 2	Alternative 3
Oak-pine woodland	MINT[1]	MINT	MINT
Conifer forested	No Effect	MINT	MINT
Dry-mesic openings	MINT	MINT	MINT
Streambanks	MINT	MINT	MINT
Wet depressions/wetlands	MINT	MINT	MINT

[1]*MINT - May Impact, Not Likely To Trend. This determination can refer to positive or negative impacts, noting simply that there would be effects to the species or habitat, but none that would cause a likely trend towards Threatened or Endangered species listing or a loss of viability.*

The effects of illegal ORV use in the Project Area have been discussed in the savanna/prairie plant discussion with regards to presenting an increase in disturbed habitat for NNIP introduction and establishment. Repair of ORV damaged lands and measures to reduce the illegal ORV usage on Forest lands would be of benefit in reducing loss of native plant habitat and creating disturbance areas conducive to NNIP.

Effects on Threatened/Endangered/Regional Forester Sensitive Plant Species

Project analysis for Threatened, Endangered and Sensitive plant species is found in the BE (see Planning Record). No federally Threatened or Endangered plant species are found in the Project Area. Five RFSS were found in the treatment stands: Oneida grape fern (*Botrychium oneidense*), ternate grape fern (*Botrychium rugulosum*), prairie smoke, furrowed flax (*Linum sulcatum*), and western silvery aster (*Symphyotrichum sericeum*). The determination of project effects for potential sensitive species is summarized in Table 3-27.

The determination of project effects for sensitive species found in the proposed treatment stands is summarized in Table 3-28.

Determination Table for RFSS Plants Found in Project Stands
Table 3-28

RFSS Plants in Project Stands	Alternative 1	Alternative 2	Alternative 3
Oneida grape fern (*Botrychium oneidense*)	MINT	MINT	MINT
Ternate grape fern (*Botrychium rugulosum*)	MINT	MINT	MINT
Prairie smoke (*Geum triflorum*)	MINT	Beneficial Effect	Beneficial Effect
Furrowed flax (*Linum sulcatum*)	MINT	Beneficial Effect	Beneficial Effect
Western silvery aster (*Symphyotrichum sericeum*)	MINT	Beneficial Effect	Beneficial Effect

The Cumulative Effects of Implementing Alternatives 1, 2, and 3

Imperiled Natural Communities, KBB Plant Species, Sensitive Plant Species and Non-Native Invasive Plant Species

Area of analysis is the western mid to southern portion of the lower peninsula of Michigan.

In the immediate Project Area there is one vegetation treatment area bordering the north boundary of the current Project Area in the previously analyzed Mast Lake Project. Within the Mast Lake Project treatment areas, treatments to restore 83 acres of dry sand prairie will be implemented in the near future. In addition, the BWC District has been restoring savanna like vegetative units in the Idelwild, Southeast-Peacock, White River/Otto Savanna Ecosystem Restoration, Big Star, and M37 Project Areas. As noted in Tables 3-3, 3-6, and 3-11, an overall 7% increase is expected on the Forest between 2014-2024 with a net decrease of 2.6% and 1.7%, respectively, for high site

oak and low site oak forested stands; a net decrease of 2.8% and 0.2%, respectively, for long-lived and short-lived conifers; and an increase of 0.4% of open lands and no net change in aspen/birch, lowland hardwoods and conifers, or northern hardwoods.

Some restoration on non-NFS lands has occured, primarily under the direction of The Nature Conservancy on nearby private lands and the Coolbough Natural Area. In addition, some prairie restoration has begun several miles to the north by the Big Prairie Township. Additional savanna habitat maintenance for KBB also occurs on some Consumer's Energy land holdings.

Outside of the above-noted treatments, oak-pine barrens and dry sand prairies would continue their State-wide trend of habitat loss due to encroachment by and succession of woody vegetation and invasive plant savanna habitat quality deterioration (MNFI 2009). Lack of fire, and other management tools to renew savanna or prairie habitat would result in a continuing trend of loss of habitat for RFSS savanna/prairie species, both on the Forest and within the historical savanna/prairie habitats of the southern to mid lower Michigan peninsula.

Further development on private lands and increased fragmentation and isolation of prairie/savanna remnants is expected in the future. This would decrease the amount of undeveloped plant habitat and increase the likely introduction of NNIP. Increased land development on private lands would create additional problems for rare plants by creating more isolated populations of rare plants and reducing genetic exchange needed for healthy populations.

Herbivory has been shown to have a significant effect on savanna or prairie herbaceous species. Small mammals have been shown to negatively affect forb species (Martinez-Garza et al 2003) through grazing, and through seed predation (Bricker et al 2010). Deer browse is also a major factor (Anderson et al 2007) affecting forb species. Management to create more savanna/prairie is likely to increase effects of herbivory on savanna, prairie and sensitive plants in the Project Area and in nearby private lands.

Major highway corridors close to the Project Area would continue to bring visitors and vehicles into this area which may result in the spread of invasive species. The Forest Service would continue to monitor and treat NFS lands adjacent to the Project Area to inhibit the spread of those NNIP of concern; however, because of the recreational use in the area, new invasive species introductions are likely. Residential road construction and development would create additional vectors for NNIP's dispersal along the network of County primary and secondary roads, and Forest roads.

All NNIP identified in surveys of the Project Area are likely to spread and occupy more of the land base in the future, although at differing rates of spread. The Forest Service has newly forming partnerships with agencies and landowners (Michigan Stewardship Network West Michigan Cooperative Weed Management Area). Cooperative efforts can increase the likelihood of effective NNIP management by addressing both public and private land holdings with NNIP present. In addition, the Forest has a wide-scale, limited-use pesticide Environmental Assessment to control and eradicate high-priority NNIP for up to 2,000 acres per year across the Forest.

Private landowners may use mechanical and chemical means to reduce the presence of weeds on privately held properties. No data currently exists to estimate how effective these treatments are in the analysis area. Agricultural landowners in the area are likely to use pesticides in their farming practices. No private agricultural lands are expected to occur in close enough proximity to the

Project Area for an effect of private lands pesticide application on proposed expanded savanna habitat.

Oak-pine barrens and dry sand prairies have been decreasing in both quanitity and quality in the southern to mid-part of lower Michigan, largely due to lack of fire and invasive plants. Oak savanna/prairie areas would continue to be encroached upon by woody vegetation on both private and public lands, making them increasingly unsuitable for savanna, prairie, nectar or RFSS plants. Lack of fire and other management tools to renew savanna and prarie habitats would result in a continuing trend of loss of habitat for these species, both on the Forest and within the historical savanna/prairie habitats of the southern lower Michigan peninsula. Creation/restoration of the savanna, prairie and dry openings habitat would create a beneficial overall effect of increasing habitat for oak-pine barrens, dry sand prairie, nectar and RFSS plant species.

Conclusion: Alternatives 2 and 3 would result in an increase in favorable conditions for savanna, prairie and open habitat RFSS plant/nectar species, and would reduce NNIP populations and spread. Alternative 2 would result in greater restoration of dry sand prairie habitat. Alternative 1 would continue to contribute to the disappearance of adequate quality habitat for savanna, prairie and open habitat plant species, and would not lessen the negative effects of NNIP on native/sensitive/nectar plant habitat.

Soil Productivity

Resource-Specific Information & Existing Condition

Soil Productivity

The Project Area is comprised of five landforms (Land Type Associations-LTAs) left at the end of the last glacial period. The overall geomorphology is a matrix of over washed moraines (dry sandy hills) within a large outwash plain (sandy plains-dissected or loamy ground moraine and outwash), having basins where organic materials have been deposited (wet sandy plains) or accumulated and dissected by the Muskegon and Little Muskegon rivers (alluvials, fluvials, and organics). The HMNF's Ecological Classification system describes its landscapes at various inventory scale units, from the largest, (LTA, thousands of acres) to the smallest, ELTP (one to perhaps a few hundred acres). LTAs correspond with how large scale topographical features (hills, plains, lowlands) were generated by the retreating glaciers. ELTPs descriptions include more specific information on local soil and vegetation properties, (including site index) and reflect potential late succession forest vegetation cover types. LTA and ELTP descriptions for the Project Area and the Forest are summarized in Cleland et al (1993).

Dry sand prairie is recognized as having an historical association with the Sparta soil series, which is located in several areas of Newaygo County (Hauser 1953). These prairies were located about 65 miles north of the Prairie Peninsula of Michigan, and despite their isolation, are similar in many respects to other prairie ecosystems. In particular, the historic West Tract and Finger prairies, and other smaller areas, are in the Project Area; remnants of these two were included in the Newaygo Prairies RNA, designated by the Forest Service in 1988. Other areas of Sparta sand soils occur on NFS and private lands in the vicinity, including areas within the Newaygo unit of the Lower Michigan Experimental Forest. These other areas have been planted to pines, or have naturally occurring oaks and other trees, shrubs and herbaceous species, but still contain elements of the

historical vegetation elements associated with dry sand prairie. Some of these locations were severely eroded by wind following conversion to agricultural uses in the past (USDA 1989).

The effects on the soil productivity from past management activities vary by location and activity. Generally, the topography, proximity to open water, depth to the water table, and the ownership objectives throughout the area has dictated the types and locations of historic management. In this area, soils that are located on well-drained sites have been repeatedly impacted by timber management or other agricultural practices. Soils in the lowland areas or adjacent to water were not extensively developed for agriculture and are now prime locations for homes and recreational uses. These areas generally exclude timber management. In upland locations on NFS lands, oak forests and pine plantations are inter-mixed with private lands; harvesting of these forestlands has occurred intermittently since the 1950s. Some plantations have been thinned before, while others have not. As a result, the landscape consists of areas that have received moderate to heavy impacts, and other areas which have received little to no impacts to soil productivity.

Human activity in the past century has led to a significant increase in nitrogen emissions via atmospheric deposition, and this has affected nitrogen cycling and NO_3 leaching, with consequences in species composition northern forests (Pardo et al 2011). Nitrogen additions may have other affects, such as enhancing carbon sequestration in the organic horizons of the soil, rather than increase forest growth, and indicate that changes in species composition will have effects on carbon and nitrogen cycling in the future (Lovett et al 2013).

For this project, the characteristics of the various soils and their capacity to sustain productivity following the various proposed activities were evaluated. The potential impacts from equipment use (e.g. compaction, rutting, erosion, and transportation system) are evaluated, as well as the potential impacts from prescribed fire and herbicide use on soil productivity. Soil typing and characteristics were first identified from existing inventories, and then verified on the ground. Areas sensitive to mechanical disturbance were dropped from treatment considerations or conservation measures were established for protection.

The soils of the Project Area are derived from coarse sands and gravels; the depth to the water table ranges from >15 feet to the surface, depending on subsoil and surface soil textures and arrangements. Soil productivity is largely determined by parent material, climate, and the amount of soil organic matter; of the three, only organic matter can be managed in forest soils. The overall amount of soil organic matter is important because this is the primary source of plant nutrients (Pritchett and Fisher 1987). Soil reaction in the top 60 inches of the dominant soil series, representing ELTPs 10-25, ranges between 4.5-8.4 pH. Soil productivity can be expressed as the average annual increment of wood produced for each combination of ELTP and Dominant Vegetation Group (USDA-Forest Service Compartment Prescription Handbook FSH 2409.21d). Table 3-29 summarizes the important landscape characteristics in the Project Area.

There are three general locations where soil erosion and displacement are occurring; these are near the railroad and Basswood Road intersection, part of the RNA, and portions of the Newaygo ESA. In all three areas, the subsoil has been exposed by illegal ORV use and natural re-vegetation is not occurring.

Landtype Associations and Related Features
Table 3-29

LTA	Landtype Association Group	Soil Features	Dominant Vegetation Group(s)	Representative ELTP's
1	Sandy plains, dissected	Poorly-developed, excessively well to restricted drained sands.	Short and long lived conifers, low-site oaks, non-forested, dry sand prairie.	10-12: Black oak white oak/blueberry on excessively well drained sands of outwash plains; sandy clay loam bands and water tables 6-15 feet may occur. Also Sparta soil series.
3	Dry sandy hills	Moderately developed, well to excessively well-drained sands.	Long-lived conifers and high-site oaks, non-forested	20-25: Mixed oaks-red maple/ starflower on well to excessively well drained sands on ice contact and overwashed topography; sandy clay loam bands and water tables 6-15 feet may occur.
4	Wet sand plains	Moderately developed, somewhat poorly drained sands.	Lowland hardwoods and conifers, non-forested.	72: Red oak-red maple/leatherleaf-vaccinum on poorly drained acid sands with a perennial water table 10-20 inches in the growing season; ortstein layer common, organic horizon < 8 inches thick.
5	Alluvial, fluvial, and organics	Organic deposits >8 inches and water table at or near the surface year long.	Non-forested, lowland hardwoods and conifers	62: Red oak red maple/ leatherleaf-blueberry on somewhat poorly drained acid sands; perennial water table 30-40 inches OR 82: White cedar-hemlock on non-acid and organic soils; ponding and open water occurs.
7	Loamy outwash and ground moraines	Moderately developed, excessively drained loams and sands	High site oaks, long-lived conifers.	31-35: Mixed oaks-red maple/viburnum on well drained sands with coarse sandy loam or finer bands 1-6 inches+ in the B-C horizons.

The Direct and Indirect Effects of Implementing Alternative 1

The analysis area for the direct and indirect effects of the treatments on soil productivity is confined to the individual areas where ground disturbing treatments using mechanical equipment, prescribed fire and other activities are proposed.

Soil Organic Matter, Compaction; Rutting, Displacement, and Erosion; Transportation System; Prescribed Fire; and, Herbicide Use

There would be no changes to soil resources caused by treatments under Alternative 1. Total biomass levels would continue to increase without harvesting. Soil productivity levels would remain similar, or increase, as organic matter accumulated within the upper soil profile. This would occur as the forested stands mature, and no events occur that export or reduce litter and

biomass. Taking no action would result in the highest above and belowground biomass levels (Pritchett and Fisher 1987).

This alternative would cause no additional forested areas to be affected by soil compaction and erosion. Soil compaction would continue to recover from past management activities as surface and below ground biomass is accumulated, natural wetting-drying-freezing events occur, and soil micro-fauna activity reduce the bulk density of affected areas (Greacen and Sands 1980). Soil compaction and displacement cause soils to lose productivity because of diminished water-holding capacity and organic matter reductions; the amount of productivity loss depends on the soil texture, the amount of displacement, as well as the depth and persistence of the compaction. Recovery from compaction could take from 8 to 12 years following commercial harvests that used tree-length skidding, and up to 40 years on roads intermittently used to remove timber products (Greacen and Sands 1980). Soil erosion would continue at locations, such as roads and recreation trails, where the slope is >2% and ground vegetation is sparse or non-existent (Pritchett and Fisher 1987).

There would be no direct or indirect impacts on soil productivity from prescribed fire and herbicide use.

However, if a large, high-intensity wildfire were to occur, the effects on the soils could become extensive. There would be an increased potential for soil erosion (from equipment use and lack of ground cover), loss of nutrients (volatilization of leafy and small woody vegetation), changes to above and below ground carbon stocks, and local soil sterilization from extreme temperatures (Hurteau and Brooks 2011).

No treatments would occur in the Newaygo Prairies RNA, and soil productivity would be affected. Further encroachment of pines and oaks would continue to reduce the area of savanna and prairie habitats and fuel loading would slowly increase, and negatively affect soil productivity for the desired species. Soil productivity in severely eroded areas of the RNA would continue to be impaired for the desired species.

The Cumulative Effects of Implementing Alternative 1

The analysis area for cumulative effects on soil productivity includes NFS lands where proposed activities would occur and vehicle use on Forest and County roads.

The soil resources in the Project Area were impacted in the late 1800s and early 1900s through logging practices, the conversion of portions of this area to agriculture and rangelands, periodic fire events, and moderate to severe wind erosion. Reforestation efforts, including tree planting furrows and mechanical harvesting operations, also impacted the soils from 1935 to 1990. Since the early 1930s, soil productivity has generally been stabilized or improved; in general, soil organic matter has been increasing as permanent vegetative cover was established. Based on the site-specific soil characteristics, the nutrients supplied by decaying organic matter is either available to the vegetation or are leached to deeper soil layers. The overall effects of the activities that have occurred have generally increased levels of nutrients available for plant use and storage as compared to the 1930s, but reduced levels occur on intensively managed areas, compared to native soil.

Alternative 1 would incrementally increase soil productivity on NFS lands within the Project Area. Dead and down timber, especially near roads, would be removed for use, principally as firewood. As individual groups of trees, shrubs, and herbaceous species complete their life cycles, general levels of biomass and soil organic matter accumulation would exceed removals and slightly benefit soil productivity. Salvage of dead and down trees, or harvests of green timber on private land within the Project Area would potentially have very small impacts to the productivity of NFS lands.

Currently, there are areas of eroding and compacted soils occur on public road locations, illegal ORV use locations, and on areas where past and future timber harvest areas (especially skid trails and landings) have received concentrated equipment use. Soil compaction, rutting, displacement, and erosion would continue to occur on areas subject to motor vehicle use. The areas affected by past harvesting and other mechanical equipment use, landings, and skid trails would continue to slowly recover through natural processes if critical physical thresholds were not exceeded in the past, and if vegetative cover were maintained (Greacen and Sands 1980); no herbicide use is proposed. The most severely affected locations, such as permanent roads, and legal and illegal motorized vehicle use areas, would continue to be adversely effected unless roads were maintained within design standards, relocated, or eliminated, and illegal uses eliminated and damaged areas re-vegetated.

Soil productivity within the RNA would be negatively affected, and impaired soil productivity areas would exist. Soil productivity for other areas of savanna and prairie would be stabilized or improved for the desired species.

Conclusion: Soil organic matter inputs on NFS lands and continuing soil impacts would incrementally add to the effects of past, present and reasonably foreseeable activities on soil productivity. Soil productivity on public roads and illegal ORV use areas could be impaired unless roads were maintained within design standards, relocated, or eliminated, and illegal uses eliminated and damaged areas rehabilitated.

The Direct and Indirect Effects of Implementing Alternative 2

Soil Organic Matter

Under the Alternative 2, the residual level of soil organic matter would vary based on the type of harvest (regeneration vs. thinning), restoration treatments, and prescribed fire intensity and frequency. Stone et al and Stone (1999 and 2000) have documented loss of site productivity effects for similar harvest sites on the Huron National Forest. Individual timber stands would experience an immediate export of site nutrients through the removal of nutrients being stored and utilized by the trees at the time of harvest. Within regeneration areas (overstory removal and shelterwood seed harvests) and conversion of forests to upland openings, this loss would be greater than in the thinnings; however, woody and herbaceous vegetation re-growth would occur rapidly. This would increase the ability of the site to recycle nutrients prior to leaching. In addition, Lederle and Mroz (1991) determined that bracken fern contributes to nutrient retention and cycling, especially if the harvests occur prior to frond maturation, i.e. mid to late summer. Tree regeneration would begin the first year after harvest. This, coupled with the extensive root systems left from the previous stand, would reduce the susceptibility of a site to short-term nutrient loss due to the erosive properties of wind and water.

Soil productivity in areas subject to commercial regeneration and upland opening maintenance treatments would not be reduced where stem wood and/or a large portion of branch wood and leafy materials are retained on site, and if re-vegetation occurs promptly (Ranger and Turpault 1999). Soil productivity in areas subject to commercial and upland opening treatments would be reduced in the short-term where stem wood and the majority of branch wood and leafy materials are removed; no measurable decline in long-term productivity would occur where these sites occur on ELTP units 20-25; on ELTP units 10-12 and 20, no measurable decline would occur if re-vegetation occurs promptly, and if rotation lengths mimic natural nutrient replenishment (Ranger and Turpault 1999). Unless the majority of woody material <4 inches in diameter from harvested trees in overstory removal areas, and a lesser amount of this material in pine thinning units, is retained on site, short-term adverse effects on soil productivity could occur. Retaining all hardwood material <4 inches in diameter would allow this topwood to reduce the negative effects of soil compaction and nutrient export, help retain above and below-ground organic matter, and provide a substrate for fungi, bacteria, and other micro-organisms in the soil (Gingras 1994, Lanford and Stokes 1995). Monitoring of recent timber sale projects has shown this to be an effective mitigation measure. Harvesting during periods of non-saturated soil conditions and plant dormancy would also sustain site productivity (Hallett and Hornbeck 2000).

Tree-length harvesting of pine trees would be permitted to facilitate reduction of fuel <4 inches in diameter. Removing the majority of conifer woody material <4 inches in diameter for all treatment areas would export approximately 23% more nutrients than a stem only harvest (Alban 1988). Inherent soil reserves, atmospheric inputs, the residual mature trees, naturally occurring seedlings, and herbaceous cover recovery and establishment would maintain the long-term productivity of all except shallow and highly siliceous sites (Pritchett and Fisher 1987). Retention of woody material helps to maintain above and below-ground organic matter and provide a substrate for fungi, bacteria, and other micro-organisms in the soil. Harvesting during periods of non-saturated soil conditions and plant dormancy would also sustain site productivity (Hallett and Hornbeck 2000). Organic matter processes and organic matter decomposers would mitigate the presence of retained woody debris as part of the fuel load within 5 years of the harvest.

The forest and shrub canopy in areas subject to dry sand prairie and savanna treatments would be greatly reduced using mechanical harvesting equipment or hand tools. This reduction in overall canopy cover would alter the existing temperature regime of the soils in these locations, causing greater seasonal flux. Seasonal increases in soil temperature would result at the sites where vegetation is removed by increasing direct solar radiation reaching the soil surface. This increase would change the dynamics of biomass accumulation by stimulating organic matter decomposition. Consequently, the thickness of the O horizon would decrease and proportionately more organic carbon would accumulate in the A and B soil horizons as the herbaceous root mass increases. This change would promote short-term nutrient mineralization that would be lost through leaching if prompt re-vegetation does not occur (Brady and Weil 2002). The magnitude of these effects would be proportional to the amount of canopy removed, the amount of soil exposed, the existing levels of organic matter at the soil surface, and the site-specific historical impact related to land use (i.e. relatively undisturbed vs. old pasture).

In the Project Area, the locations where the activities associated with dry sand prairie and savanna restoration/creation would occur are found on soils with ELTP units 10, 11, 12, and 24. The soils associated with these ELTPs have deep, sandy profiles. The depth to the water table in these ELTPs is >15 feet (except 3.5-6 feet on ELTP 24), and the thickness of the O horizon (fresh and decomposing organic material) in these units is variable, but averages 0-1 inch thick. The upper

soil layers in all of these ELTP units have low nutrient content and cation exchange capacities (Cleland et al 1993). Typically, the highest soil productivity for tree species occurs in ELTP unit 224, and is associated with its comparatively thick layer of humus and a well-defined "A" horizon (topsoil). Once herbaceous vegetation is established, deep rooted species (e.g. lupine, big and little bluestem, and oaks) exploit subsurface soil layers for moisture and nutrients. The establishment of these species is dependent on the favorable growing-season soil moisture and a mineral seedbed that promotes germination. Pennsylvania sedge and bracken fern compete for moisture in the upper soil layers, and reducing the amount of these two species would be necessary to establish other savanna plant species.

Dry sand prairie restoration treatments would severely displace and reduce the organic matter levels by removing all trees, uprooting considerable numbers of stumps, and using prescribed fire to reduce the existing conifer litter. Low to moderately severe prescribed fires would reduce the organic matter and increase, for a short while, the nutrient availability. This is especially important for nitrogen, some of which volatilizes, and like other nutrients, is converted to chemical forms readily available for plant use. Prescribed fire would also increase soil pH for a short time as alkaline cations are released from burned organic matter, further stimulating plant growth (Certini 2005). The microbial community biomass would be decreased by prescribed fire, especially that of fungi and soil dwelling invertebrates. These effects would be of a short duration if plants quickly are re-established and if prescribed burns occur when moisture levels simultaneously prevent total consumption of organic matter and limit the transmission of extreme temperature into the soil profile. Soil fertility for herbaceous species would be amended by lime application if the pH is <5.5 after the initial prescribed fire. Mechanical equipment would be used to seed and prepare the seedbed for grasses and forbs where stumps are removed, which would reduce soil bulk density over approximately 10% of each restoration unit. Soil bulk density where stumps are removed would be partially restored by the weight of mechanical equipment and by using compacting equipment to increase seed contact with the soil. A short-term net loss of soil productivity would accompany these treatments, primarily through leaching, until the root mass of the grassland species fully occupies the upper soil profile (Miller and Donahue 1990). Brye and Kucharik (2003) found that the carbon to nitrogen ratio in the top 25 centimeters was not significantly related to ecosystem age. This was found in the restored prairies in Wisconsin after 24 years in coarse textured soils, and suggested that the rate of carbon accumulation over this period of time reaches an equilibrium following restoration from agricultural use. As the mollic soil horizon becomes renewed, soil productivity would begin to be restored, but approximating natural soil organic carbon levels in disturbed soils may take a century (Potter et al 1999).

Mechanical treatments to expose mineral soil would have small, temporary effects on soil productivity, hastening decay and exposing disturbed areas to small-scale wind erosion. Mechanical site preparation for seeding would be coordinated with strip application of herbicides, particularly where Pennsylvania sedge mats are dense. In situations where mechanical cultivation is necessary, the depth of humic material mixing within the profile would increase. The amount of disturbance would depend on the amount of the residual vegetation and the physical obstacles of each site (e.g. stumps and slash) and the growing requirements of the plants being seeded, but would typically not exceed a depth of 6 inches. Soil organic matter would be affected by mechanical equipment used for site preparation and seeding of herbaceous species. The effects would be limited to humus disturbance and nutrient mixing within 10-20% of the treated areas, moving organic matter from the O and A horizons to the B horizon, and altering the composition of nutrients available for emerging seedlings (Troeh et al 2004). Mechanically cultivated sites

would be seeded using mechanical equipment and hand tools and are expected to become fully vegetated within two growing seasons of treatment.

Prescribed fire treatments would occur in the Newaygo Prairies RNA, and soil productivity would be affected. Encroachment of pines and oaks would be reduced, and the area of savanna and prairie habitats and fuel loading would slowly decrease, and positively affect soil productivity for the desired species. Soil productivity in severely eroded areas of the RNA would continue to be impaired for the desired species, as these areas would not receive any treatments.

A comparison of these direct effects is displayed under Alternative 3 in Table 3-31.

Appendix A contains conservation measures to reduce the adverse effects on soil organic matter; therefore, the effects of organic matter would be local in scale and minor in severity.

Compaction, Rutting and Displacement

Heavy equipment use would occur on all commercially harvested areas, and would not cause a measurable loss of inherent soil productivity if properly mitigated. Soil disturbance would occur on collector skid trails, where more passes occur than with only single-pass tree felling and loading. This would not be detrimental to soil productivity if a small percentage of the area (i.e. <15%) received these impacts. As the root systems of the felled trees decay, water infiltration would increase. This increase would be due to channeling and would provide increased nutrient and microorganism mobility in these areas. The effects related to this would work to slowly reverse the effects of compaction present as a result of harvesting activities. The soils that dominate the outwash plains are not as susceptible to compaction as finer clay soils, due to the reduced aggregate surface area that results from large individual particle size and the depth of the sand layer in these areas. The effects of harvesting activities in other areas are dependent on the amount and location of clay layers (Pritchett and Fisher 1987). In general, harvesting equipment traffic in thinning treatments make more trips over a skid trail, as compared to the regeneration treatments where skidding would be dispersed. Greater soil compaction and mineral soil exposure and displacement would occur using tree-length harvesting equipment, especially on collector skid trails and landing sites (Gingras 1994, Lanford and Stokes 1995), as compared to cut-to-length equipment. Compaction effects on landing areas and temporary access roads would be increased due to the intense use of harvesting equipment. If soil disturbance is <15% of each treatment area (as measured by a bulk density increase of <15%, a rutting depth of <6 inches, and displacement of the forest floor in which <1 inch of the subsoil is at the surface layer), then its effects would be local in scale and minor in severity. Recovery from compaction would occur over a period of many years, but have fewer adverse effects on sandy soils than in other soils (Stone 1999, 2000).

There would be soil compaction from the use of mechanical equipment used to restore the barrens/savanna cover type. Harvesting methods for restoration would facilitate dispersed skidding (except at landings). This would minimize the number of concentrated skid trails within each location. Where compaction occurs on skid trails and landing sites, mechanical site preparation and seeding would reduce the bulk density of these sandy soils by increasing aeration, water infiltration, and herbaceous vegetation recovery. Mechanical equipment use to till and seed herbaceous species would have small, temporary soil compacting and disturbing effects, principally within areas not impacted by heavier equipment. The effects of mechanical equipment from prescribed burning and the seeding of native plant species would result in short-term soil displacement where prescribed fire control lines are constructed, and where mineral seedbeds are

prepared. Fire-line construction would occur on the perimeter of many locations, and be rehabilitated and seeded afterwards using mechanical equipment and hand tools.

Prescribed fire treatments would occur in the Newaygo Prairies RNA without soil disturbance; control lines would be established using a combination of mowing with a farm-style tractor and brush hog-style mower, and/or use of an ATV to establish a water (wet) line. Soil disturbance in severely eroded areas of the RNA would continue to be impaired for the desired species, as these areas would not receive any treatments.

Chapter 2 contains conservation measures to reduce the adverse effects of soil compaction, rutting, and displacement; therefore, the effects of compaction, rutting, and displacement would be local in scale and minor in severity.

Erosion

There would be very small amounts of soil erosion resulting from this alternative. Mechanical equipment would be used for harvest operations, prescribed fire control line construction, and tilling and seeding of restored and maintained openings. Lighter equipment used for mechanical treatments of upland openings, such as farm tractors, ATVs, and attachments would cause negligible soil erosion because disking and tilling result in rapid herbaceous re-vegetation following the treatment. These sites would become re-vegetated within one growing season, which would restore ground cover and reduce the effects of the disturbance. The planned location for skid trails and temporary roads and landings for the treatment units would not be placed near riparian areas, and would be placed on slopes <15% and <5%, respectively. Prompt re-vegetation of these sites, using either natural or supplemental methods (e.g. traffic barriers, water-bars, and herbaceous seeding) would stabilize the disturbed areas and reduce erosion.

The sandy soils, high infiltration rates, and relatively flat terrain of the proposed restoration sites would limit accelerated erosion caused by equipment use in these locations. Savanna sites would continue to have a density of large or regenerating trees and herbaceous vegetation sufficient to stabilize, or re-vegetate, exposed mineral soil if the displacement of the forest floor does not exceed 40% of any location, and if any one displaced sub-location does not exceed 0.1 acre in size. Landing sites and heavily-used skid trails would be susceptible to the erosive forces of water due to exposure of mineral soils in some of these locations; however, if surface infiltration is not impeded by compaction, and skid trail slopes are <6%, the erosion hazard is slight.

Prescribed fire treatments in the Newaygo Prairies RNA would not cause soil erosion; control lines would be established using a combination of methods that would not expose mineral soil. Prescribed fire intensity, sufficient to reduce the density of trees <8 inches in diameter at the ground line would consume small amounts of litter and duff, and would expose mineral soil on a few microsites. Herbaceous vegetation would recover, fully restore ground cover, and prevent soil erosion. Soil erosion in severely eroded areas of the RNA would continue to be impaired for the desired species, as these areas would not receive any treatments.

A comparison of the direct effects of compaction, rutting, displacement, and erosion are displayed under Alternative 3 in Table 3-31.

Treatments associated with heavy equipment uses would comply with the State of Michigan BMPs for harvesting (MDNR 1998) and (USDA-Forest Service Eastern Region Handbook 2509.18,

Chapter 2). Mitigation for skid trails and landings can also be found in Appendix A; therefore, the effects of erosion would be local in scale and minor in severity.

Transportation System

Under this alternative, roads and landings constructed for timber harvest activities would temporarily remove vegetation, compact soil, and expose soil to erosion. Amacher and O'Neill (2004) demonstrated through the use of a small penetrometer that soil compression in compacted trails and areas were 2 and 3 times as great as adjacent undisturbed areas. Temporary roads and landings would begin to be re-vegetated after use and rehabilitation is concluded; this would begin to restore ground cover one growing season later. Permanent County and Forest roads would also be affected by the traffic from hauling timber products, resulting in periods where increased compaction and rutting would occur on non-paved roads.

Road and landing construction activity reduces existing amounts of soil organic matter by removal and erosion. Areas of unimproved roads (County, local, and the HMNF's maintenance Level 1 and 2) would continue to be the most susceptible to erosion, as these areas are typically void of vegetation and decaying organic matter. Construction activities in these locations typically include gravel surfacing and local drainage controls, such as culverts and ditches; afterwards, these roads receive very little maintenance. Susceptibility to erosion and compaction and rutting would vary by location due to site-specific conditions and the amount of vehicle traffic received. On most of these roads, topography plays a key role, where the surface soil horizons from higher elevations is washed off by precipitation and settles in lower elevations. This, in conjunction with the erosive forces of vehicle tire treads, leads to the formation of gullies and wash-out in areas where the slope is >2%. Compaction would continue to increase the bulk density of the soils in and along roadways open to vehicle use. In some areas, the affected sites would expand due to the development of by-pass roads to avoid wet pockets in the roadbed and the expansion of roads from the current NFS road system.

The Project Area is served by County and State highways that are intended for passenger car vehicles; these roads are improved and maintained to protect the integrity of the roadbed and drainage investments. Compaction, rutting, and erosion occur on these roads, but are mitigated by routine maintenance; however, long-term compaction and erosion of the roadbed into riparian areas and drainages occur. Operating ORVs causes soil compaction and displacement; on NFS lands, use of these vehicles occurs illegally on Forest roads and open areas, such as the Newaygo Prairie ESA.

A comparison of these direct effects is displayed under Alternative 3 in Table 3-31.

Treatments would comply with the State of Michigan BMPs for harvesting (MDNR 1998) and (USDA-Forest Service Eastern Region Handbook 2509.18, Chapter 2). Mitigation for soil compaction, mineral soil displacement, and nutrient export can be found in Chapter 2. Mitigation for skid trails and landings can also be found in Appendix A. Therefore, the effects of compaction, rutting, and displacement would be local in scale and minor in severity.

Prescribed Fire

The sites proposed for burning include upland openings, pines, pines-oaks, and oak forest cover types, including the dry sand prairie and savanna restoration areas. These are found on soils

associated with ELTPs 10-12, and 24, having deep sandy profiles. The depth to the water table in these soils is 3.5-15 feet. The depth of the duff layer in most of these units is variable, but averages 1" in most stands. There is a small variation among these ELTPs regarding nutrient availability. The upper soil layers in all of these ELTP units have reduced nutrient contents and cation exchange capacities (Cleland et al 1993). However, once vegetation is established, deep rooted species (e.g. lupine, bluestem, and oaks) exploit deep soil layers for moisture and nutrients. The establishment of these species is dependent on the soil moisture in the first few feet of soil. Retaining humus and retaining/restoring herbaceous and forest vegetation within 1 or 2 years of the mechanical and prescribed fire treatments is critical to sustaining soil productivity. Dense herbaceous vegetation, a more efficient user of moisture in the upper soil layers, is more easily obtained than tree regeneration.

Forested Area of Pines and Oaks

Prescribed fire effects on soil physical and chemical properties depend on the amount and duration of soil heating and soil moisture content when the fire occurs. When soil organic matter is combusted, the stored nutrients are either volatilized or are changed into highly available forms that can be taken up readily by microbial organisms and vegetation. Those available nutrients not immobilized are easily lost by leaching. Nitrogen (N) is the most important nutrient affected by fire, and it is easily volatilized and lost at relatively low temperatures; this loss is especially important on low fertility sites, and is replaced by N-fixing organisms or atmospheric inputs. Cations are not easily volatilized and usually remain in the humus and ash layers in a highly available form (Neary et al 2005). Areas exposed a level of fire intensity (150-300 BTU/ft/sec.) would have an immediate and short-term increase of nutrients at the soil surface through the deposition of nutrient-rich ash on the upper soil layers, and the volatilization of nitrogen in the humus layer. Prescribed fire activities of this intensity generally increase the availability of calcium, magnesium, and potassium via combustion of soil organic matter; "N", and phosphorus (P) are modestly decreased from volatilization, but the majority of soil organic component of these nutrients are converted to forms that are either readily available to plants or soon lost through leaching. In acid soils, "P" chemically binds to aluminum, iron, and manganese oxides (Certini 2005), and is resistant to leaching. This change in nutrient status and chemical status would be of short duration (1-3 years) as the nutrients are used by the existing vegetation, adhere to soil particles, are leached through the soil profile, or lost to transport (i.e. wind and water). Boerner and Brinkman (2003) found that, especially on more mesic sites, prescribed fire could slow nutrient recycling by increasing the amount of recalcitrant organic matter (i.e. charcoal effects). Prompt re-vegetation with permanent woody and/or herbaceous vegetation would restore physical properties (temperature, infiltration) and nutrient levels (calcium, magnesium, potassium) similar to that of pre-fire conditions (Pritchett and Fisher 1987). If nitrogen-fixing species are included in the re-growth, burning activities may restore the original nitrogen pool in the soil (Certini 2005). Natural recovery of microorganisms (invertebrates, fungi, bacteria) would occur over a period of one to three years (Ahlgren and Ahlgren 1965). Soil carbon levels and profiles would be affected by the type of vegetation dominating after the fire: where woody species dominate, carbon balances are restored to pre-fire conditions as the trees mature. In contrast, where herbaceous species are dominant, both the amount and location of soil carbon are changed (Miller and Donahue 1990). Total nitrogen losses, incurred by volatilization and leaching, are compensated by increased mineral forms (available to plants) of nitrogen due to increased mineralization rates (Pritchett and Fisher 1987) and atmospheric inputs (Boerner and Brinkman 2003).

In most areas that would remain forested, the desired range of fire intensity would be between 150-300 BTU/ft/sec. These intensity levels would be sufficient to kill pines <5 inches in diameter at the ground line, and top-kill the majority of oaks <2 inches in diameter at the ground line (Bova and Dickinson 2005), and reduce the load of the <1 inch diameter dead fuels; trees >6 inches in diameter survive this fire intensity range. Prescribed fires having this level of intensity on similar sites on the HMNF have resulted in <15% mineral soil exposure (Hatting 2014).

A short-term impact to soil productivity would occur under this alternative, but the intensity would vary by the amount and type of vegetation, site-specific soil characteristics. The existing fuel load reference (National Wildfire Coordinating Group (NWCG) 1999) for woody dead and down materials is 1.7 tons/acre, and locally observed values are typically <1.0 ton/acre (Borgman 2014). Soil productivity in areas affected by prescribed fire and commercial harvesting would not be reduced in the short-term if mineral soil is exposed on <15% of the area, and soil moisture levels reduce the amount of humus layer consumption. The expected amount of exposed mineral soil in any location would be <15%, and considering that the prescribed burns would be low to moderate-intensity fires, and would occur within 5 days of rainfall >0.25 inch, are expected to marginally reduce the humus layer (Hatting 2014).

Areas to be treated only with prescribed fire activities would be similarly affected as those where no vegetation treatments would occur. Prescribed burning only would affect organic matter by reducing the total amount of live woody vegetation (e.g. stems and leaves) and organic matter in the O layer, and contributing to the volatilized of N nutrients, with a slight reduction in cation exchange capacity in the humus layer. The existing fuel load reference (NWCG 1999) for woody dead and down materials is 3.8 tons/acre, and locally observed values are typically 1.0 ton/acre (Borgman 2014). The expected amount of exposed mineral soil in any location would be <15%. Considering that the prescribed burns would be low to moderate-intensity fires, and would occur within 5 days of rainfall >0.25 inch, they are expected to marginally reduce the humus layer. The combination of low fire intensity and short duration would decrease short-term porosity of the mineral soil where runoff catches ash and other fine debris in existing depressions (Hatting 2014).

Dry Sand Prairie and Savanna Restoration Areas

Prescribed burning and hand and/or no-till mechanical seeding would be used for both seed bed preparation and seeding in dry sand prairies and savannas. The amount of disturbance would depend on the amount of the residual vegetation, the physical obstacles of each site (e.g. stumps and slash), and restoration treatment following the prescribed fire, such as site preparation and the seeding methods employed and the growing requirements of the plants being seeded. Dry sand prairie restoration treatments would severely displace and reduce the organic matter levels by removing all trees, uprooting considerable numbers of stumps, and using prescribed fire to reduce the existing conifer litter. Low to moderately severe prescribed fires would reduce the organic matter and increase, for a short while, the nutrient availability. This is especially important for nitrogen, some of which volatilizes, while some is converted to ammonium, readily available for plant use. Prescribed fire would also increase soil pH for a short time as alkaline cations are released from burned organic matter, further stimulating plant growth (Certini 2005). The microbial community biomass would be decreased by prescribed fire, especially that of fungi and soil dwelling invertebrates. These effects would be of a short duration if plants quickly are re-established and if prescribed burns occur when moisture levels simultaneously prevent total consumption of organic matter and limit the transmission of extreme temperature into the soil profile. Soil fertility for herbaceous species would be amended by lime application if the pH is

<5.5 after the initial prescribed fire. Mechanical equipment would be used to seed and prepare the seedbed for grasses and forbs where stumps are removed, which would reduce soil bulk density over approximately 10% of each restoration unit. Soil bulk density where stumps are removed would be partially restored by the weight of mechanical equipment and by using compacting equipment to increase seed contact with the soil. A short-term net loss of soil productivity would accompany these treatments, primarily through leaching, until the root mass of the grassland species fully occupies the upper soil profile (Miller and Donahue 1990). Treated sites would be expected to become fully vegetated within two growing seasons of the activity. As the "A" soil horizon becomes renewed, soil productivity would begin to be restored, but approximating natural soil organic carbon levels in disturbed soils may take a century (Potter et al 1999). Brye and Kucharik (2003) found the carbon to nitrogen ratio in the top 25 centimeters in the restored prairies in Wisconsin after 24 years in coarse textured soils; they suggested that the rate of carbon accumulation over this period of time reaches an equilibrium following restoration from agricultural use.

Newaygo Prairies Research Natural Area

Prescribed burning would only be used to reduce woody stem encroachment in one location of the RNA (T12N R12W, section 2 NENW), approximately 25 acres. Two low to moderately severe prescribed fire would reduce the organic matter and increase, for a short while, the nutrient availability. This is especially important for nitrogen, some of which volatilizes, while some is converted to ammonium, readily available for plant use. Prescribed fire would also increase soil pH for a short time as alkaline cations are released from burned organic matter, further stimulating plant growth (Certini 2005). The microbial community biomass would be decreased by prescribed fire, especially that of fungi and soil dwelling invertebrates. These effects would be of a short duration if plants quickly are re-established and if prescribed burns occur when moisture levels simultaneously prevent total consumption of organic matter and limit the transmission of extreme temperature into the soil profile. A short-term net loss of soil productivity would accompany these treatments, primarily through leaching, until the root mass of the grassland species fully occupies the upper soil profile (Miller and Donahue 1990). Treated sites would be expected to become fully vegetated within one growing season of the activity.

An estimated 14-19 miles of constructed (plowed) control line would be required to conduct all the broadcast burns; Forest and County roads would also serve as control lines. While not all burn units, and their accompanying control lines, would be burned at the same time, it can be assumed that control lines established using mechanical equipment would increase the potential for soil erosion. Soils in the proposed treatment areas are typical of outwash plains, where erosion would primarily be limited to areas of mechanically constructed fire control lines where slopes are >2%. However, this potential for erosion would be mitigated because the topography of the area is generally flat, control lines would be temporary and be established shortly before ignition, and after the prescribed burn has been conducted the control lines would be rehabilitated.

There would be approximately 28% more acres of upland openings in Alternative 2 as compared to Alternative 3; because open areas are attractive locations for illegal vehicle use, the risk of increased soil displacement and erosion is greater in Alternative 2 than in Alternative 3. Unless illegal vehicle use is mitigated by effective barriers, re-vegetation, and law enforcement, a greater amount of impaired soil quality is likely to occur.

A comparison of the direct effects of prescribed fire are displayed under Alternative 3 in Table 3-31.

The burn plans written for prescribed burn areas contain conservation measures to reduce the adverse effects of prescribed fires and restoration activities. The burn plans also contain conservation measures to reduce the adverse effects of prescribed fire treatments; therefore, the effects of broadcast burning in forested areas, and the effects of broadcast burning and site preparation for dry sand prairie and savanna restoration would be local in scale and minor in severity.

Herbicide Use

The herbicides and adjuvants identified for application in the Project Area (glyphosate, triclopyr) are known to degrade within the soil profile through various photochemical, chemical, or biological (microbial metabolism) reactions. Herbicides may be immobilized by adsorption to soil particles or uptake by non-susceptible plants. These processes isolate the herbicide and prevent it from moving in the environment. Adsorption is often dependent on the soil/water pH, and generally increases with increasing soil organic content, clay content, and cation exchange capacity. Adsorption is also dependent on water solubility, with less soluble herbicides being more strongly adsorbed to soil particles. Ester formulations are generally the least water solvent, and are therefore more strongly adsorbed by soil particles. In addition, ester formulations are more volatile than salt or acid formulations, and are therefore more easily evaporated from soil and plant surfaces or leached down into the soil (Tu et al 2004).

The commercial formulation of glyphosate (including the surfactants and inert ingredients) has a benign effect on the microbial community structure when applied at the recommended field rate in forest soils having clay loam and sandy loam textures (Ratcliff et al 2006). There does not appear to be any adverse effects on soil microorganisms from applications of imazapic when used as an effective herbicide; however, it may persist in soils of arid regions, and does not bind tightly to alkaline soils with low organic matter (Tu et al 2004). The effects of triclopyr on soil microorganisms suggest that a transient inhibition in the growth of some bacteria or fungi could be expected. This could result in a shift in the population structure of microbial soil communities, but substantial impacts on soil (i.e. gross changes in capacity of soil to support vegetation) would not be likely (USDA 2004b).

An herbicide's persistence in the soil is often described by its half-life, or the time it takes for ½ of the herbicide applied to the soil to degrade from its original chemical structure. The half-life can vary depending on soil characteristics (i.e. texture, pH), weather (i.e. temperature and soil moisture), and the existing vegetation at the application site (USDA 2004b).

Table 3-30 illustrates the interaction that the herbicides proposed to be used have within the soil, and pertains to Alternatives 2 and 3.

These herbicides, principally glyphosate, would be used for spot-treatment of one large and numerous small, dispersed locations of NNIP, as described in the NNIP section of this document. Application would occur using ground-based mechanical and hand-tools; most treatment locations would be augmented by using hand tools to remove NNIP. Specific information related to the use of glyphosate, triclopyr, and imazapic are documented in the Planning Record.

Herbicide Mobility and Persistence in the Soil[1]
Table 3-30

Herbicide	Mechanism of Degradation	Half-life in the Soil	Mobility
glyphosate	Degradation is primarily due to soil microbes.	Average of 47 days	Glyphosate has an extremely high ability to bind to soil particles, preventing it from being mobile in the environment.
imazapic	Degraded primarily by microbial metabolism.	31-233 days	Imazapic is weakly adsorbed in high pH soil. Adsorption increases as the pH decreases and with increasing clay and organic matter content. There is little lateral movement of imazapic in soil.
triclopyr	Rapidly degraded to triclopyr acid by photolysis, microbes in the soil, and hydrolysis.	30 days	Ester formulation binds readily with the soil, giving it low mobility. The salt formulation binds only weakly in soil, giving it higher mobility (%). However, both formulations are rapidly degraded to triclopyr acid, which has an intermediate adsorption capacity, thus limiting mobility.

[1]*Tu et al, 2004*

A comparison of the direct effects of herbicide application are displayed under Alternative 3 in Table 3-31.

The Cumulative Effects of Alternative 2

The soil resources in the Project Area were impacted in the late 1800s and early 1900s through logging practices, the conversion of portions of this area to agriculture and rangelands, periodic fire events, and moderate to severe wind erosion. Reforestation efforts, including tree planting furrows and mechanical harvesting operations, also impacted the soils from 1935 to 1990. Since the early 1930s, soil productivity has generally been stabilized or improved; in general, soil organic matter has been increasing as permanent vegetative cover was established. Based on the site-specific soil characteristics, the nutrients supplied by decaying organic matter is either available to the vegetation or are leached to deeper soil layers. The overall effects of forest vegetation growth and atmospheric inputs that have occurred have generally increased levels of nutrients available for plant use and storage as compared to the 1930s, but reduced soil productivity has diminished on intensively managed areas, compared to native soil.

Live vegetation on NFS lands would be treated with a variety of management activities; approximately 29% of the red pine plantations proposed for treatment have had prior commercial harvests; none of the other areas proposed for treatments have had organic matter removals since inception of the existing forest cover. The majority of the existing forest vegetation has red and jack pine, oak, or oak-pine forests suited for future timber production using the same suite of treatments as proposed; dead and down timber could also be removed for use as firewood. Those cover types containing red pine, aspen, and oaks are likely to be managed for timber products and wildland fire hazard reduction in the foreseeable future.

As individual groups of trees, shrubs, and herbaceous species are felled or otherwise complete their life cycles, general levels of biomass and soil organic matter accumulation would exceed removals, except for commercially regenerated areas. Soil productivity would not be affected by intermediate treatments because the remaining vegetation would retain and replenish nutrients sufficient to offset biomass removals (Pritchett and Fisher 1987). Soil productivity in areas subject to repeated, intensive commercial treatments, such as thinning and regeneration treatments, would be reduced in the short-term where stem wood and the majority of branch wood and leafy materials are removed (Stone 2002). However, these treatments would be implemented on a sufficiently long rotation i.e. 45+ years, and would therefore mitigate organic matter depletion. As these forested areas regenerate and/or continue to mature during the ensuing decades, organic matter would accumulate and replenish exported nutrients. Long-term productivity of upland opening sites would be mitigated by maintaining adequate tree and herbaceous vegetation cover to retain and modestly enhance organic matter in mineral soil horizons. All areas, including stands to be less intensively treated, would receive atmospheric inputs (especially nitrogen) and biotic accruals that would sustain soil productivity and further mitigate nutrient depletions (Ranger and Turpault 1999); in addition, retention of hardwood topwood would conserve organic matter. Soil productivity would be protected or slightly enhanced by ensuring that continuous vegetation canopies, dominated by either forest or herbaceous species, follow natural or anthropological disturbances.

The range of rotation lengths for lands suited for timber management in MAs 4.2 and 4.4 are 45 to 100 years, respectively; however, final harvest may occur when the CMAI is attained at the stand level (HMNF 2012c). Rotation lengths in this range, which would be typical for dry sandy sites, should allow for natural recovery of soil productivity.

Currently, areas of eroding and compacted soils occur on public roads, illegal vehicle use locations, and timber harvest areas, especially skid trails and landings that have received concentrated equipment use. Soil compaction, rutting, displacement, and erosion effects would continue to occur on those areas unless otherwise restored to the natural range of soil bulk density, i.e. re-vegetation. These impacts, caused by harvesting, illegal ORV use, mechanical planting, prescribed fire and wildfire control, landings, skid trails, and streamside access, would recover, at various rates, through natural processes if critical physical thresholds were not exceeded during historic periods, or are not exceeded in the future, and vegetation cover is maintained. The most recent timber harvests occurred 10-20 years ago; some Forest and County roads have been affected by previous harvests, and would be affected by future harvests. The most severely affected locations are permanent roads and legal and illegal motorized vehicle use areas; these would continue to be adversely affected unless maintained within design standards, relocated, or eliminated.

Some areas treated with herbicides would also be treated with broadcast burning or pile and burning. The active ingredients and adjuvants of glyphosate, triclopyr, and imazapic would bio-degrade within 1-5 months; prescribed fire treatments occurring after this period of time would not affect soil or air resources.

The proposed prescribed fire treatments within some locations of the Newaygo Unit of the Lower Michigan Experimental Forest areas have been previously broadcast burned; these locations are upland openings. One of these locations recently had, and other areas proposed for prescribed fire treatments, likely have had some small (<10 acre) wildfires. These treatments and incidents have

been of short duration and low to moderate fire intensities, and have not impaired soil productivity.

Soil productivity within that part of the RNA treated with prescribed fire would be stabilized or improved for the desired species; however, impaired soil productivity areas would exist.

The Project Area has a mixed ownership of NFS and private lands. Private lands are expected to be further subdivided, developed, and be owned primarily for residential and recreational purposes. The primary effect on NFS lands would be the use of vehicles and ORVs for overland travel because of greater opportunity, such as more open areas, and reduced tree density.

Conclusion: The duration and magnitude of the proposed treatments in Alternative 2 would incrementally add to past, present, and reasonably foreseeable capability of the soil resource to produce specified plants or plant succession (soil productivity), primarily by conserving soil organic matter and top-soil, retaining sufficient amounts of these features so that existing soil productivity is sustained following intensive treatment, and by promoting/retaining continuous herbaceous and forest canopy vegetation. Soil productivity is likely to suffer declines where the effects of past and on-going erosion, compaction, and organic matter retention are not ameliorated.

The Direct and Indirect Effects of Implementing Alternative 3

Soil Organic Matter, Compaction, Rutting and Displacement, Erosion, Prescribed Fire, and Herbicide Use

Alternative 3 differs from Alternative 2 in location and scale of effects. The types of treatments in Table 2-1: *Treatment Activities by Alternative* are otherwise similar between the two alternatives. Therefore, only the relative effects will be addressed in this section; other direct and indirect effects are the same as addressed in Alternative 2. The basis for relative impact ratings are explained below.

Prescribed fire effects on soil physical and chemical properties would occur on approximately 38% more acres in Alternative 3 than in Alternative 2; the amount of broadcast burning would account for the majority of this increase. An estimated 14-19 miles of control line would be required to conduct all the broadcast burns. While not all burn units, and their accompanying control lines, would be burned at the same time, it can be assumed that control lines established using mechanical equipment would increase the potential for soil erosion. However, this potential for erosion would be mitigated because the topography of the area is generally flat and erosion potential would be reduced by the lack of slope, existing roads frequently serve as control lines, control lines would be temporary and be established shortly before ignition, and after the prescribed burn has been conducted the control lines would be rehabilitated.

The soil productivity impacts in Table 3-31 displays the effects of proposed treatments on soil productivity between Alternatives 2 and 3. The principal differences between Alternatives 2 and 3 are the total amounts and spatial arrangement of regeneration and intermediate harvests and upland opening treatments, fuel reduction activities, short and long term transportation system changes, and herbicide applications.

In Table 2-1, vegetative treatments acres and additional treatment acres (only counting mechanical/manual woody vegetation removal as one applied activity) is the source of the

treatment acres used in the measurements below; the Project Area contains 7,676 acres of NFS land.

Comparison of Treatment Effects on Soil Productivity - Alternatives 2 and 3
Table 3-31

Soil Productivity Impact(s)	Generator of Effect	Alternative	Measurement Factor	Relative Impact[5]
Organic Matter Accumulation	Removing and establishing vegetation.	2	2389:5287 = 0.45[1]	Medium
		3	2232:5444 = 0.41[1]	Medium
Compaction, Displacement, Rutting, Erosion	Mechanical equipment use.	2	(147 x .4) + (3174 x .2)/7676 x 100 =8.1% [2]	Low
		3	(103 x .4) + (2829 x .2)/7676 x 100 = 7.9%[2]	Low
Soil chemistry and physical properties	Broadcast Burn.	2	1628:6048 = 0.27[3]	Low
		3	1446:6230 = 0.23[3]	Low
Soil chemistry and physical properties	Herbicide application: average soil persistence	2	47:31-233:30[4]	Equivalent
		3	47:31-233:30[4]	

[1]*Ratio of all intermediate treatments to regeneration plus opening/savanna treatments.*
[2]*Net % of all treated acres where equipment >2 tons GVW is used.*
[3]*Ratio of broadcast burn acres to untreated acres.*
[4]*Average soil persistence. Refer to Table 3-30.*
[5]*Level of impact refers to the relative impacts between Alternatives2 and 3 only*

Relative impact comparisons rank soil productivity impacts by alternative based on the following:

- **Organic matter accumulation** on treated (all commercial and non-commercial activities) vs. non-treated acres.
- **Compaction, rutting, and erosion** use an estimate of felling and forwarding equipment coverage of all commercially harvested areas; regeneration and opening creation/restoration harvests average 40%, and intermediate harvests and opening restoration/maintenance/mechanical woody vegetation removal average 20% ground disturbance, using either cut-to-length or whole-tree equipment or other equipment >2 tons GVW.
- **Soil chemistry and physical properties** use a ratio of these effect generators on treated (all broadcast burning) vs. non-treated acres.
- **Herbicide application** is ranked by ratio of active ingredients soil persistence among products that would be applied.

Transportation System

Table 3-32 displays the amount of soil disturbing activity generated by mechanical equipment include construction and reconstruction of County and Forest roads, closure of Forest roads, and road/stream crossing improvements, and change in Forest Road maintenance levels.
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Estimated Lengths of Roads and Acres of Landings - Alternatives 2 and 3
Table 3-32

Alternative	Miles/Number of Locations Permanent Construction	Miles/Number of Locations Temporary Construction	Acres of Landings/ Number	Number of Road-Stream Crossing Improvements	Change in Miles of Forest Road Levels	
					Level 1	Level 2
Alternative 2	7.2/15	3.85/27	30/55	9	0	-3.9
Alternative 3	7.2/15	3.85/27	30/55	9	0	-2.8

Under Alternative 3, the effects on the Project Area's soil resource would be local in scale and minor in intensity; the acres that could be harvested using tree-length harvesting equipment than in Alternatives 2 and 3 are essentially the same. The amount of acres proposed for treatments in regeneration harvesting, new upland opening creation, and plantation pine thinning are different in both the number of locations and amount of acres between these alternatives. However, the access for proposed mechanical harvesting and road-stream crossing improvements is not different between Alternatives 2 and 3.

There would be approximately 28% fewer acres of upland openings in Alternative 3 as compared to Alternative 2; because open areas are attractive locations for illegal vehicle use, the risk of increased soil displacement and erosion is greater in Alternative 2 than in Alternative 3. Unless illegal vehicle use is mitigated by effective barriers, re-vegetation, and law enforcement, a greater amount of impaired soil quality is likely to occur.

Treatments would comply with the State of Michigan BMPs for harvesting (MDNR 1998) and (USDA-Forest Service Eastern Region Handbook 2509.18, Chapter 2). Additional conservation measures can be found in Appendix A.

The Cumulative Effects of Implementing Alternative 3

Under Alternative 3, 9% fewer acres of live vegetation and 9% fewer acres would have compaction, rutting, displacement and erosion potential caused by equipment use, as compared to Alternative 2. Therefore, Alternative 3 provides for marginally greater protection of the soil resource than does Alternative 2. NFS lands on outwash plains and low sandy hills containing conifer or mixed oak-conifer forests within and adjacent to the Project Area are likely to be managed for timber products and wildland fire hazard reduction in the foreseeable future, such as the Chase Red Pine Project and other fuels projects. Other cumulative effects on soil productivity are the same as discussed in Alternative 2.

The amounts of soil compaction, rutting, displacement, and erosion are likely to continue to occur on Forest and County roads throughout the Project Area from vehicle use are similar under Alternatives 2 and 3. The most severely affected locations are permanent roads and legal and illegal motorized vehicle use areas; these would continue to be adversely affected unless maintained within design standards, relocated, or eliminated.

The proposed prescribed fire treatments within some locations of the Newaygo Unit of the Lower Michigan Experimental Forest areas have been previously broadcast burned; these locations are upland openings. One of these locations recently had, and other areas proposed for prescribed fire treatments, likely have had some small (<10 acre) wildfires. These treatments and incidents have been of short duration and low to moderate fire intensities, and have not impaired soil productivity.

Soil productivity within that part of the RNA treated with prescribed fire would be stabilized or improved for the desired species; however, impaired soil productivity areas would exist.

The Project Area has a mixed ownership of NFS and private lands. Private lands are expected to be further subdivided, developed, and be owned primarily for residential and recreational purposes. The primary effect on NFS lands would be the use of vehicles and ORVs for overland travel because of greater opportunity, such as more open areas, and reduced tree density. This potential effect is less under Alternative 3 as the amounts of upland openings treated are fewer than in Alternative 2.

Conclusion: The duration and magnitude of the proposed treatments in Alternative 3 would incrementally add to past, present, and reasonably foreseeable capability of the soil resource to produce specified plants or plant succession (soil productivity), primarily by conserving soil organic matter and top-soil, retaining sufficient amounts of these elements so that existing soil productivity is sustained following intensive treatment, and by promoting/retaining continuous herbaceous and forest canopy vegetation. Soil productivity is likely to suffer declines where the effects of past and on-going erosion, compaction, and nutrient export are not ameliorated.

Risk to Public Health, Safety, and Private Property from High-Intensity Wildfire, Prescribed Burning, and Emissions

Resource-Specific Information & Existing Condition

The area of analysis for this issue includes all the lands within the Project Area, as well as areas within Newaygo County. Newaygo County is where the majority of the Project Area is located and where the fuels reduction portions of the project are occurring. There is habitat restoration work for the KBB occurring in small portions of Mecosta and Montcalm Counties.

A primary purpose of the Bigelow-Newaygo Project is to reduce the possibility of a high-intensity wildfire by disrupting the continuity of fuels in pine-dominated stands and reducing the overall fuel loading in the Project Area. It has been determined that the Bigelow-Newaygo Project is critical due to the combination of three factors:1) the population numbers, housing density and property values in and around the Project Area; 2) the overall fire hazard of the area; and, 3) the history of fire occurrences in and around the Project Area.

Population, Housing Density and Value

The Bigelow-Newaygo Project Area is located within Brooks, Evert, Croton and Big Prairie Townships of Newaygo County, Aetna Township, Mecosta County and Reynolds Township, Montcalm County, Michigan. Table 3-33 is a breakdown of US Census data for the six townships that encompass the Project Area, including population and housing figures.

US Census Data for Townships Encompassing the Project Area[1]
Table 3-33

	Brooks - Newaygo County	Everett - Newaygo County	Big Prairie - Newaygo County	Croton - Newaygo County	Aetna - Mecosta County	Reynolds - Montcalm County
Population	3,521	1,912	2,560	3,235	2,232	5,266
Total Housing Units	2,122	991	1,597	1,794	918	2,128
Occupied	1,477	757	1,063	1,323	783	2,028
Vacant or Seasonal	645	234	534	471	135	100
Housing per sq. mile	~62	~28	~44	~49	~26	~59
Estimated Value of Housing Units	152 million	59 million	79 million	144 million	59 million	168 million

[1]*U.S. Census 2008-2012 American Community Survey 5-Year Estimates*

The combined population of the six townships that account for the entirety of the Project Area is approximately 18,726 individuals. The housing density for the six townships ranges from 62 structures per square mile (both occupied and vacant/seasonal) in Brooks Township to 26 structures per square mile in Aetna Township (US Census 2011).

The estimated value of owner-occupied homes in the six townships ranges from approximately $59 million dollars in both Everett and Aetna Townships to approximately $168 million dollars in Reynolds Township. The total estimated value of owner-occupied homes in the six townships that encompass the Project Area is approximately $661 million dollars (US Census 2011). This does not include the value of commercial property and housing units other than owner-occupied homes present in these townships.

Hazard Rating

The Project Area was identified in the 2010 Newaygo County Community Wildfire Protection Plan (CWPP) as having a Composite Community Assessment Rating of *High*. This rating is based upon the following factors: fuels rating, ignition risk, values, protection capabilities, catastrophic

fire potential, and fire history. There were five townships in Newaygo County that received a *High* determination and three of them make up portions of the Project Area: Brooks, Croton, and Everett Townships. The hazard ratings for Aetna and Reynolds Townships have not been determined at this time.

The fuels portion of the project concentrates on treating the forest cover to reduce the fire hazard in the area, treating primarily jack and red pine stands, which are the most volatile tree species present in the Project Area. The habitat restoration portion of the Project has treatments in conifer, hardwood, and grasslands within the Project Area.

Acres and Percentage of Stands by Fuel Type on National Forest System Lands in the Project Area
Table 3-34

Forest Type	Acreage	% of Total
Jack Pine	88	1%
Red/Jack Pine and Oak	142	2%
Red and White Pine	2,428	31%
Mixed Oak	3,493	46%
Open	739	10%
Other	786	10%
TOTAL	**7,676**	

The jack and red pine-dominated stands have the greatest potential for high-intensity wildfire, and are considered one of the most volatile fuel types occurring in the United States or Canada (Anderson 1982). Approximately 3% of the Project Area is forested with jack pine-dominated stands, while another approximately one-third (31%) of the area is forested with red pine-dominated stands (Table 3-34). While the pine timber types have the greatest potential for high-intensity wildfires the oak types also contribute to the high risk rating for the area. Oak forest types are especially hazardous after reaching maturity and starting to fall apart. This usually occurs when stands reach 70+ years on sandy soils. Over 90% of the oak stands in the Project Area are over 70 years old. This leads to large areas with increased fuel loadings on the ground with increased complexity to the suppression effort.

Fire Starts

The history of fire occurrences in the Project Area is an important factor in the decision to implement the Bigelow-Newaygo Project. Utilizing data from the CWPP for grass, wood and illegal burn fire starts for the years 2005 through 2009, the data shows that 228 fires occurred in Big Prairie, Brooks, Croton and Everett Townships, Newaygo County. This is approximately 46 a year.

The data shows, and personal observations concur, that the area is experiencing growth in the number of homes and structures and, likely, a corresponding increase in the number of people living in the wildland-urban interface (WUI). Statistical fire causes are overwhelmingly due to human factors, estimated at greater than 98% of the fire starts, again reflecting the influence of the WUI (Forrest 2005). Therefore, as the population continues to increase within and around the

Project Area, and as more structures are built, the number of fire starts can be expected to correspondingly increase, as well as the amount of damage these fires could potentially cause.

Fire Regimes

The current vegetation in the Project Area is characterized by one of three natural (historic) fire regimes (HMNF 2012c):

Fire regime 1 is represented by jack pine stands and openings. This fire regime is characterized by frequent (e.g. 0-35 years) stand-replacing fires (jack pine stands) and low-intensity fires (openings). Historically, this fire regime would have been critical in the maintenance of jack pine stands, openings, and barrens.

Fire regime 2 is represented by red pine and red pine-jack pine stands, especially those with contiguous crowns and which are adjacent to jack pine stands. This fire regime is characterized by relatively frequent stand-replacing fires (e.g. 0-50 years) where most trees are killed.

Fire regime 4 is represented by northern black, northern red, and mixed oaks; red maple; and, aspen. This fire regime is characterized by less frequent mixed intensity ground maintenance fires (e.g. 50-100 years) where there is a mosaic of different ages of forested stands and openings (Hann and Bunnell 2001).

Condition Classes

The Project Area is classified according to its condition class, which is based on its departure from the historic fire regimes described above. Presently, the Forest Service is working on a map that displays the HMNF according to its current condition class. For now, the data on condition class in the Project Area is a consensus of opinion of the HMNF's fire specialists.

Extensive areas within the HMNF are determined to be either fire condition class 2 (moderate departure from the historic regime), or condition class 3 (high departure from the historic regime).

Condition class 1 occurs where historical fire regimes are within their historical range (Schmidt et al 2002). Vegetation attributes are intact and functioning within a historical range. There are no stands within the Project Area that reflect a condition class 1.

Condition class 2 occurs where historical fire regimes have been moderately altered from their historical range (Schmidt et al 2002). The negative aspects of being in a condition class 2 includes the moderate possibility of losing key components of the ecosystem, an increase in fire size, intensity, and its effect on the landscape, although less so than condition class 3. This condition class is associated with moderate hazard. The only stands within the Project Area that reflect a condition class 2 are upland openings and remnant prairies.

Condition class 3 occurs where historical fire regimes have been altered from their historical range (Schmidt et al 2002). The majority of the Project Area is considered to be in condition class 3. The negative aspects of being in a condition class 3 includes the high possibility of losing key components of the ecosystem, and an increase in fire size and intensity due to an increase in fuel build up and arrangement. In condition class 3, fire hazard is relatively high and the fire intensity is more severe, impacting large trees that would normally survive fires of lower intensity. This

condition class is associated with high hazard based on the danger posed to people and the potential for long-term resource damage.

In the discussions of condition class that take place in this document, the condition class is treated as a continuum; i.e. a particular stand can be moved from a condition class 3 to some point in a condition class 2, either close to a condition class 3 or a more substantive change that would bring it closer to a condition class 1. For example, a stand that is currently in condition class 3 could be moved part way into a condition class 2 by utilizing mechanical methods only, but that simulate to some lesser degree what would take place with its natural fire regime. On the other hand, a stand might be mechanically treated and then followed by a fire regime which is closer to the natural fire regime of the stand, thus moving it closer to a condition class 1. In addition, there could be a multiplicity of stages between these two options that would also fall into condition class 2.

One of the goals of the Forest Plan is to treat forests currently in condition class 3 in order to move them towards condition class 2, or if practical towards condition class 1 (Table 3-42). The management options available to move forested stands from condition class 3 to a class 2 may require the use of treatments that utilize hand cutting or mechanical methods, followed by the reintroduction of fire into the ecosystem utilizing prescribed burning. Where appropriate and reasonable, forested stands in condition class 2 would require moderate levels of restoration treatment, with emphasis on the continued use of prescribed fire as a restoration tool.

Fuel Models

Forest fuels are classified into four basic groups that are based on the dominant vegetation type - grass, brush, timber, and slash. The differences in fire behavior within these groups are related to the total fuel load and how that fuel load is distributed among the different sized particles that make up the fuel loading of a stand. Fuel load and depth are measurable fuel properties used for predicting the odds a fire will be ignited, its rate of spread, and its intensity (Anderson 1982).

Fire behavior fuel models found in the Bigelow-Newaygo Project Area include models 1, 4, 5, 8, and 9. The stands to be treated are comprised primarily of fuel models 1, 4, and 9 (92% of acreage to be treated). Smaller areas are represented by fuel models 5 and 8 (8% of acreage) (Table 3-35). Acres treated in each alternative, by forest type and fuel model, are also displayed in Tables 3-40, 3-41.

The representative fuel models are described in detail below (Anderson 1982):

Fuel Model 1 - Fire spread is governed by the fine, very porous, and continuous herbaceous fuels that have cured, or are nearly cured. Fires are surface fires that move rapidly through the cured grass and associated material. Very little shrub or timber is present. Grasslands and barrens/savannas, along with stubble, grass-tundra, and grass-shrub combinations, represent this model. Annual and perennial grasses are included in this model, and total fuel loadings are approximately .74 tons per acre.
In the Project Area, fuel model 1 is currently represented by grass and forb-dominated openings. Fuel model 1 accounts for approximately 9% of the Project Area.

Forest Type and Fuel Model Acreage of National Forest System Lands in the Project Area
Table 3-35

Forest Type	Fuel Model	Total Acreage[1]	% of Area
Open (Grasslands)	1	739	9
Jack and Scots Pine	4	88	1
Lowland Brush	5	126	2
Upland Brush	5	26	<1
Aspen	8	263	3
Mixed Lowland Hardwood/Conifer	8	210	3
Oak and Eastern White Pine	9	236	3
Oak and Aspen	9	76	1
Black and White Oak	9	1,445	19
Red and White Pine	9	2,428	31
Red Pine/Oak and Jack Pine/Oak	9	142	2
Mixed Northern Hardwoods	9	161	2
Mixed Oak and& Red Maple	9	1,736	23
TOTAL		**7,676**	**100**

[1]*All acres are approximate.*

Fuel Model 4 - Fire intensity and fast-spreading fires involve the foliage and live and dead fine woody material in the crowns of a nearly continuous secondary overstory. Stands of mature shrubs, 6 or more feet tall, such as California mixed chaparral, the high pocosin along the east coast, the pine barrens of New Jersey, or the closed jack pine stands of the north-central states are typical candidates. Besides flammable foliage, dead woody material in the stands contributes to the fire intensity. Height of stands qualifying for this model depends on local conditions. A deep litter layer may also hamper suppression efforts. Fuel loading is typically 16.03 tons per acre.

In the Project Area, fuel model 4 is represented by jack pine stands. Fuel model 4 accounts for approximately 1% of the Project Area.

Fuel Model 5 - Fire is generally carried in the surface fuels that are made up of litter cast by the shrubs and the grasses or forbs in the understory. The fires are generally not very intense because surface fuel loads are light, the shrubs are young with little dead material, and the foliage contains little volatile material. Usually shrubs are short and almost totally cover the area. Fuel loading is typically 3.5 tons per acre.

In the Project Area, fuel model 5 is represented by lowland and upland brush openings. Fuel model 5 accounts for approximately 3% of the Project Area.

Fuel Model 8 - Slow-burning ground fires with low flame lengths are generally the case, although the fire may encounter an occasional "*jackpot*" or heavy fuel concentration that can flare up. Only under severe weather conditions involving high temperatures, low humidity's, and high winds do the fuels pose fire hazards. Closed canopy stands of short-needle conifers or hardwoods that have leafed out support fire in the compact litter layer. This layer is mainly needles, leaves, and

occasionally twigs because little undergrowth is present in the stand. Fuel loading is typically 5 tons per acre.

In the Project Area, fuel model 8 is represented primarily by white pine-dominated, red maple-dominated, and aspen stands. Fuel model 8 accounts for approximately 6% of the Project Area.

Fuel Model 9 - Fires run through the surface a little faster than model 8 and have longer flame heights. Both long-needle conifer stands and hardwood stands, especially the oak-hickory types, are typical. Fall fires in hardwoods are predictable, but high winds can actually cause higher rates of spread than predicted because of spotting caused by rolling and blowing leaves. Closed stands of long-needled pine like ponderosa, Jeffrey, and red pines, or southern pine plantations are grouped in this model. Concentrations of dead-down woody material will contribute to possible torching out of trees, spotting, and crowning. Fuel loading is typically 3.48 tons per acre.

In the Project Area, fuel model 9 is represented by red pine, red pine-oak, mixed pine, and oak-dominated stands. Fuel model 9 accounts for approximately 81% of the Project Area.

Fuel Loading

The fuel models described above include a figure for total fuel loading, given in tons per acre. That figure for fuel loading can be further broken down into four sub-categories based on the diameter of the fuel particles. These different sized particles are referred to as 1-hour, 10-hour, 100-hour, and 1000-hour fuels based on the time it takes the fuel to adjust to such environmental inputs as humidity and precipitation, called the timelag (Pyne et al 1996). As described in Pyne: "When a change occurs, the moisture moves toward a new equilibrium. How quickly these fuels gain or lose moisture in response to wetting and drying cycles establishes their response time."

One-hour timelag fuels include particles less than one-quarter inch in diameter. Ten-hour timelag fuels include those particles in the one-quarter to one-inch diameter size class. One-hundred hour timelag fuels include those fuel particles from one to three inches in diameter. Based on the description of timelag above, fuels less than one-quarter inch in diameter would react to environmental inputs within one hour, while particles between one and three inches in diameter would take 100 hours to reach the same moisture content.

In addition, there is a class of fuel particles referred to as 1000-hour fuels. These particles are larger than 3 inches in diameter, and would take 1000 hours to reach anew moisture equilibrium. One-thousand hour fuels are a relatively minor contributor to fire intensity. They are less likely to burn than the other size fuel particles, especially the 1-hour fuels, but when they do combust they burn for a longer period of time, thus increasing fire residency. Figures for this class of fuels are not given in the data provided in this document.

The amount of moisture content in live fuels, such as grasses, needles, and leaves, are controlled less by environmental factors and primarily by internal physiological mechanisms of the plant. Table 3-36 breaks down the total fuel loading into the individual subsets (Anderson 1982).

While total fuel loading is an important factor affecting fire behavior, the fuel category that contributes the greatest to high-intensity crown fires is the live component. It is fuel model 4, represented by jack pine and jack pine-dominated stands respectively, which have a large amount of their fuel source in the needles of living trees, as well as overall fuel loading. This fuel model

accounts for approximately 1% of the Project Area with an additional 2% in the red and jack pine mixed stands. The smaller fuels, especially the less than one-quarter inch and the one-quarter inch to one inch, contribute to surface fire intensity. High fuel loading in these smaller categories can cause a light to moderate-intensity surface fire to trigger a high-intensity crown fire.

Average Fuel Loading Subsets by Fuel Model
Table 3-36

Fuel Model	Fuel Size - tons per acre				
	<¼ inch	¼ to 1 inch	1 to 3 inch	Live	Total
1	0.74	0.00	0.00	0.00	0.74
4	5.01	4.01	2.00	5.01	16.03
5	1.00	0.50	0.00	2.00	3.50
8	1.50	1.00	2.50	0.00	5.00
9	2.92	0.41	0.15	0.00	3.48

By modifying the vegetation structure, amount, and continuity, the fire behavior could be changed from a potential crown fire to a surface fire. A surface fire would have shorter flame lengths and slower rates of spread thereby allowing safe direct attack by suppression forces. Direct attack would allow for increased protection of adjacent structures and resources.

Related Actions

Newago County through their CWPP has identified areas on private property in need of fuels treatment (Table 3-37). Four of these areas fall with the project boundaries of this analysis. The Forest Service assisted the Newaygo County Emergency Services Director in the design and layout of these projects whose scope was to reduce hazardous fuels on private property in the County. The projects involved the cutting, piling & burning, chipping or removal of high hazard trees and brush. It also included educating landowners in additional *Firewise* techniques that can done on their properties.

Fuel Treatment Activities Conducted in the Project Area under Newaygo County CWPP
Table 3-37

Name	Size/Acres	Completed
Oak Avenue	137	Yes
Hardy Pines Subdivision	20	Yes
Chestnut and Cypress Avenues	225	On going
Margaret Avenue	22	Yes
TOTAL	404	

Safety

Federal wildland fire policy states that firefighter and public safety is the first priority in every fire management activity (USDI, USDA 2014). Prescribed fire plans and activities must reflect this

commitment. Every person involved in a prescribed fire is committed to identifying safety issues and concerns. It is the responsibility of those individuals participating in prescribed burn activities to notify their immediate supervisor of any possible misunderstanding of assigned tasks or safety concerns related to the assignment.

Risks and uncertainties relating to fire management activities must be understood, analyzed, communicated, and managed as they relate to the cost of doing or not doing an activity. In the burn plan process actions should be developed to minimize or eliminate threats and manage risks.

Prescribed fires present an inherent level of risk. Risk is at all levels, for decision makers, fire fighters and homeowners and the public. The overall prescribed fire planning process includes a risk assessment, and reflects an understanding of the interaction of objectives and implementation limitations for the project. For prescribe fire, the risk assessment is accomplished by completing the complexity analysis process that identifies, analyzes and characterizes the potential hazards, threats, causes and consequences. The complexity analysis process identifies critical items, mitigation measures and implementation actions to be addressed in the prescribed fire plan and would acknowledge any remaining unmitigated risk in the final rating. Agency administrators, duty officers, and burn bosses have a stake in the final decision to burn or not to burn. Through their interaction a determination to burn should be sound and logical decision.

Past, Present, and Future Federal Actions within the Bigelow-Newaygo Project Area
Table 3-38

Federal Actions within the Project Area Related to Fire and Fuel Treatments	Past	Present	Future
Timber harvest and reforestation activity	●	●	●
Opening creation, restoration, and maintenance	●	●	●
Savanna creation, restoration, and maintenance	●	●	●
Prescribed fire activities	●	●	●
Non-commercial manual and mechanical woody vegetation removal	●	●	●
Wildfires	●	●	●
Forest Service road maintenance and right-of-way clearing	●	●	●

Past, Present, and Future Non-Federal Actions within the Bigelow-Newaygo Project Area
Table 3-39

Estimated Non-Federal Actions within Project Area Related to Fire and Fuels Treatments	Past	Present	Future
Private utility company construction and maintenance of utility rights-of-ways	•	•	•
Private timber and reforestation activities	•	•	•
Newaygo County road maintenance	•	•	•
Wildfires	•	•	•
Prescribed fire activities by TNC, Michigan Nature Association, and private landowners	•	•	•
Residential and commercial development and landscaping	•	•	•
Opening creation and maintenance by private landowners	•	•	•

During implementation of the burn, personnel will continuously evaluate risk with an eye towards maintaining a safe work environment, meeting the burns objectives and addressing social and political concerns such as safety and smoke management. The burn boss will sign the *Go-No Check List* to identify any changes to the unit or surrounding area and to make sure contingency resources are available. At this time private parties that where interested in notification should have been notified. If all pre-burn considerations and preparation work is completed, the burn boss can move on to their test fire. If test fire is satisfactory then the prescribed fire can be carried out according to the burn plan.

The Direct and Indirect Effects of Implementing Alternative 1

If no activity were undertaken to reduce the fuel loading in the Bigelow-Newaygo Fuels Project Area the hazard rating of the area would remain in the high category. Of the primary factors affecting the hazard rating of an area the only one that can be altered is the vegetation component. As long as large acreages of mixed pine-dominated stands persist in the area the prognosis would be for the area to remain in the high hazard category.

The historical fire regimes in the Project Area would not be reinstated and the threat of high-intensity stand-replacing fires would continue to be a reality.

The condition class of the Project Area would remain in condition class 3 with a high departure from the historical condition of the area. Therefore, there would be a higher probability of a fast moving stand-replacing fire that is difficult to control.

The fuel loading of the stands found in the Project Area would continue to increase. It is expected that over time, with no treatment in the area, that the threat of a high-intensity crown fire would likely increase as the jack pine and oak mature and die (Table 3-40, 3-41). This is due to the

nature of these stands. Ageing stands regenerate two ways, either totally with a stand-replacing disturbance or incrementally with die off of individual trees. As die off continues dead wood is deposited on the forest floor increasing fuel loadings at the same time young trees are growing up through the canopy creating ladder fuels that can transport a ground fire to the canopy. While the life span of jack pine and oak can be as high as 150 years, the species matures in 60 years and subsequently begins to deteriorate, especially on poor growing sites. As these stands become over-mature (>70 years old), the buildup of volatile surface and sub-canopy fuels will increase dramatically. Therefore, as the threat of a crown fire continues with the death of the mature jack pine and oak, there will also be an accompanying increase in the surface fuels that can cause moderate to high-intensity surface fires.

Mechanical Treatments - By Fuel Model - Total Acreage and Acreage to be Treated by Alternative on National Forest System Lands in the Project Area

Table 3-40

Fuel Model	Total Acreage[1,2]	Alt 1	%	Alt 2	%	Alt 3	%
1	749	0	0	370	49	368	49
4	88	0	0	22	25	22	25
5	152	0	0	6	4	6	4
8	473	0	0	0	0	0	0
9	6,224	0	0	2,034	33	1,878	30
TOTAL	**7,676**	**0**	**0**	**2,432**	**32**	**2,274**	**30**

[1]*Both mechanical treatments and burning treatments may occur on the same acres. See the Planning Record for site specific treatments occurring within each treatment unit*
[2]*All acres are approximate.*

Approximately 60% of the existing jack pine stands in the Project Area are in excess of 60 years old, while approximately 66% of the jack pine-oak stands are greater than 70 years old. The fuel loading situation would be similar in the red pine stands. Presently, there is a high loading of potentially volatile live aerial fuels in the red pine stands that could contribute to a high-intensity crown fire. At the same time, the amount of dead surface fuels on the floor of these red pine stands is relatively small. However, if these red pine stands are left untreated and begin to succumb to increased competition from overcrowding, the fuel loading of the dead surface fuels would likely increase.

If no action is taken none of the fire behavior characteristics of the treatment area would likely change in the near term. Intensity and rates of spread would be weather-dependent on any given fire day. On a day with a moderate to high fire danger, only indirect attack could be attempted safely by fire suppression forces, and running crown fires could happen when low fuel moisture occurs. Firefighter safety and property would be especially in danger from running crown fires during the spring season when weather and low fuel moistures provide the greatest likelihood of extreme fire behavior.

The Cumulative Effects of Implementing Alternative 1

The fuel loading in the Project Area and the subsequent fire hazard associated with it would continue to be a threat to the WUI found throughout the Project Area.

Burning Treatments - By Fuel Model - Total Acreage and Acreage to be Treated by Alternative on National Forest System Lands in the Project Area

Table 3-41

Fuel Model	Total Acreage[1,2]	Alt 1	%	Alt 2	%	Alt 3	%
1	739	0	0	426	58	424	57
4	88	0	0	22	25	22	25
5	152	0	0	6	4	6	4
8	473	0	0	0	0	0	0
9	6,224	0	0	1,205	19	1,054	17
TOTAL	**7,676**	**0***	**0**	**1,659**	**22**	**1,506**	**20**

[1]*Both mechanical treatments and burning treatments may occur on the same acres. See the Planning Record for site specific treatments occurring within each treatment unit.*
[2]*All acres are approximate.*

On private lands in and around the Project Area, it is likely that development will continue in the form of additional homes and structures, both permanent and seasonal. Along with this increased development there would likely be a corresponding increase in the population of the area, both people living permanently in the WUI and those who use the land seasonally, such as hunters and other Forest users. As the population of the area increases, there would likely be an increased possibility of human-caused fires in and around the Project Area, which is the number one cause of wildfires on the HMNF. The increased opportunities for wildfire starts could result in damage not only to the public resources of the Project Area, but an increase in the damage to private property and structures, as well as an increased hazard to Forest users.

The Direct and Indirect Effects of Implementing Alternative 2

Canopy and ladder fuels that contribute to the high hazard rating of the Project Area would be modified, using primarily mechanical harvesting and prescribed burning (Tables 3-40, 3-41). By thinning dense red pine plantations and by reducing the amount of jack pine in stands, the most difficult to control fuel source, the aerial fuels, would be broken up and their threat reduced. Fires originating on the ground would not have an opportunity to move into the canopy and trigger a high-intensity fire.

Surface fuels in all forest types that can cause intense and damaging wildfires can also act as a trigger to start a crown fire, and would be modified using prescribed fire and mechanical harvesting as management tools. Mechanical harvesting can reduce total fuel loading, and combined with a variety of prescribed burning techniques, the amount of surface fuels would be further reduced. Broadcast burning (burning taking place over a specific area) performed at the appropriate time is the method that would be used. Small surface wildfires would lack the fuel necessary to allow the fire to move into the canopy of the forest and start a crown fire.

An estimated 29 miles of control line would be required to conduct all the broadcast burns (Table 2-1). While not all burn units, and their accompanying control lines, would be burned at the same time, it can be assumed that the more control line that requires monitoring the greater the opportunity for a fire escape. Therefore, Alternative 2 would have the highest potential for an escaped prescribed burn.

Multiple prescribed burns would be used to eliminate a large proportion of the fine fuels that contribute to high-intensity surface fires. These prescribed fires would be used periodically to maintain a low density of trees and encourage the development of grass and herbaceous fuels that are easier to control.

The maintenance of upland openings and savannas would prevent these openings from succeeding into forested stands, thus preventing an increase in the fuel loading in the Project Area. Where upland openings are maintained with periodic burning, surface fuels would consist of primarily grasses and forbs that burn with less intensity. Regeneration of aspen stands and clones within stands would also add to the discontinuity of the forest canopy thus reducing the hazard and intensity of crown fires.

The high hazard rating that is prevalent throughout the Project Area would be reduced through the manipulation of primarily pine-dominated stands. Although certain aspects of the high hazard rating cannot be altered (i.e. soil type, landtype), one of the most critical contributing factors to the rating, namely the vegetative composition of the area, would be altered in such a way as to reduce the hazard.

Moving the forest of the Project Area to a more accurate representation of what was present prior to European settlement would take, in most cases, several steps. This representation would be a mix of oak and pine forest types with a more open canopy and an understory of native grasses and herbaceous plant species. There would be an increase in the acreage of savannas and prairies within the Project Area. Throughout most of the Project Area the most we could accomplish during the time frame of this project would be to move the forest closer to a condition Class 2 (Table 3-42). However, there are some stands in the Project Area that would be moved closer to a condition class 1. These stands would be a close approximation of the European pre-settlement forest structure found in portions of the area. In these stands the use of mechanical methods to make large changes to the structure followed with a prescribed burn would move them toward a condition class 1 and simulate the natural fire regime as closely as possible.

Projected Change in Condition Class on National Forest System Lands in the Project Area by Alternative

Table 3-42

Alternative	Condition Class 3	Moving Toward Condition Class 2	Moving Toward Condition Class 1
1	7,676	0	0
2	7,676	2,432	2,274
3	7,676	1,659	1,506

In all the stands to be managed in the Project Area, which are currently in condition class 3, we would attempt to alter the present condition class in one of two ways. The jack pine dominated stands, which historically would have experienced periodic high-intensity, stand-replacing fires (fire regime1 and 2), would not be allowed to revert to their natural fire regime, except in small isolated jack pine stands within larger burn units, where the effects of limited crown fires would be minimal. Overall, the stands of jack pine and jack pine-oak in the Project Area would be modified in such a way as to prevent them from experiencing a crown fire. This modification would take place in the form of mechanical treatments followed by prescribed broadcast burning. These broadcast burns would be low-intensity surface fires and so would not represent the natural fire regime of these stands. Therefore, the condition class would convert to a condition class 2, close

to a condition class 1, but not a total conversion due to a moderate departure from the historical fire regime for these types of stands in this area.

At the same time other fire regimes would be reintroduced in an attempt to change the condition class from a condition class 3 to a condition class 1. One fire regime that would be reintroduced would be frequent, low-intensity fires (fire regime 1), such as those found in grass openings. This would effectively move the openings in the Project Area from a condition class 3 toward a condition class 1.

There would also be an attempt to return less frequent and mixed intensity fires (fire regime 3) to some stands in the Project Area, primarily in conifer-hardwood mix types. These stands would also be initially treated with mechanical methods, followed by a return of the historical fire regime. This would then move these stands towards a condition class 2.

The alteration of the fuel models found in the Project Area would include the reduction of areas considered to be in fuel model 4 (Table 3-40, 3-41). These stands have high fuel loadings and are susceptible to high-intensity crown fires. By reducing the amount of the live fuel loading in the pine stands, and especially jack pine stands, the threat of a stand replacing wildfire occurring would be minimized. In addition, the openings (fuel model 1) to be treated, which are characterized by light-intensity surface fires, would be maintained. Throughout the Project Area, with the widespread utilization of prescribed burning, the result would be an overall reduction of all the smaller fuel particles in every stand to be treated with fire. By reducing the total fuel loading of these stands, surface fires would be of lower intensity and the suppression actions more successful and, therefore, less likely to transition to a crown fire.

By modifying the vegetation structure, amount, and continuity, the fire behavior could be changed from a potential crown fire to a surface fire. A surface fire would have shorter flame lengths and slower rates of spread (except in fuel model 1), thereby increasing the probability that direct attack activities by suppression forces would be successful. Direct attack would allow for increased protection of adjacent structures and resources.

Alternative 2 would reduce the intensity and rate of spread of any fire originating in or burning into the treatment areas, thereby allowing direct suppression activities and providing for greater margins of firefighter safety. Smoke emissions would be of temporary duration, and have seldom been an issue in the Great Lakes region due to absence of topographic features and generally good atmospheric dispersal.

Alternative 2 would reduce ladder fuels and alter the existing continuous forest canopy by breaking up its continuity. This would result in a surface fire with reduced flame lengths and rates of spread. Approaching crown fires would become surface fires within the treatment areas. The shorter flame lengths and reduced spread rates would allow for direct attack by suppression forces on an average fire day.

With pine regeneration likely to continue in the future, along with the accompanying increase in the amount of ladder fuels, it is expected that the Project Area would have to be periodically treated for fuels. Time frames would depend on site-specific characteristics based on field reviews, but it is anticipated that a fuels treatment would need to be conducted within a twenty-year period.

The Cumulative Effects of Implementing Alternative 2

Implementing Alternative 2 would contribute to the overall reduction of the fuel loading in the Project Area and the potential for high-intensity crown fires would, subsequently, be diminished as well. The Project Area has a high hazard potential from a damaging wildfire. Alternative 2 would contribute to the reduction of this threat in combination with other fuel reduction projects occurring in the near term. A fuels project, the Baldwin Fuels Project, due south of the current area, is currently being implemented. These combined projects would contribute to the overall safety of the private lands in the area by dealing with critical areas with heavy fuel loadings on NFS lands.

However, since forested stands, and thus their associated fuel loadings, are dynamic systems, it is expected that fuels in the Project Area would continue to be managed for decades. In the case of the Bigelow-Newaygo Project, it is expected that a series of prescribed burns may be needed to affect forest type and structure of the area. It is anticipated that additional fuels projects would need to be implemented in the same area as forested stands mature, especially pine-dominated stands, and as fuels continue to amass in the area as part of the natural progression of forests.

On private lands in and around the Project Area, it is likely that development would continue in the form of additional homes and structures, both permanent and seasonal. It also can be anticipated that private landowners would likely clear forested areas, in order to build structures, and harvest timber. Along with this increased development there would likely be a corresponding increase in the population of the area, both people living permanently in the WUI and those who use the land seasonally, such as hunters and other Forest users. As the population of the area increases, there would likely be an increased possibility of human-caused fires in and around the Project Area, which is the number one cause of wildfires on the HMNF. The increased opportunities for wildfire starts could result in damage not only to the public resources of the Project Area, but an increase in the damage to private property and structures, as well as an increased hazard to Forest users.

The Direct and Indirect Effects of Implementing Alternative 3

The identified proposed fire and fuel treatments for Alternative 3 are identical to Alternative 2. All the treatments described for Alternative 2 would occur with adjustments that result in an overall acreage reduction of 339 acres. Adjustments were made to accommodate discussions between Agency specialists and public comments. The biggest changes are a reduction in the number of openings and savannas created and maintained.

An estimated 28 miles of control line would be required to conduct all the broadcast burns (Table 2-1). While not all burn units, and their accompanying control lines, would be burned at the same time, it can be assumed that the fewer control lines that require monitoring the lesser the opportunity for a fire escape. Therefore, Alternative 3 would have the lower potential for an escaped prescribed as compared to Alternative 2. By decreasing the amount of broadcast burning, there would be a smaller reduction in the fine fuel loading. However, broadcast burning is the only practical method of reducing the smallest sized fuel particles over a widespread area.

The conversion of stands in the Project Area from a condition class 3 towards either a condition class 2 or condition class 1 would be reduced.

One fire regime that would be reintroduced would be frequent, low-intensity fires (fire regime 1), such as those found in grass openings. This would effectively move the openings in the Project Area from a condition class 3 towards a condition class 1. The amount of openings that would be moved towards a condition class 1 would be less than found in Alternative 2.

There would also be an attempt to return less frequent and mixed intensity fires (fire regime 3) to some stands in the Project Area, primarily in conifer-hardwood mix types. These stands would also be initially treated with mechanical methods, followed by a return to the historical fire regime. This would then move these stands initially towards a condition class 2, then towards a condition class 1 following the prescribed burning. This would also take place on a smaller scale as that described for Alternative 2.

The Cumulative Effects of Implementing Alternative 3

Implementing Alternative 3 would contribute to the overall reduction of the fuel loading in the Project Area and the potential for high-intensity crown fires would, subsequently, be diminished as well. The combination of fuels reduction in the Project Area, combined with the Newaygo County Fuels Projects would reduce the possibility of a high-intensity wildfire damaging private lands and destroying important forested stands on NFS lands.

However, since forested stands, and thus their associated fuel loadings, are dynamic systems, it is expected that fuels in the Project Area would continue to be managed for decades. In the case of the Bigelow-Newaygo Project, it is expected that a series of prescribed burns maybe needed to affect forest type and structure of the area. It is anticipated that additional fuels projects would need to be implemented in the same area as forested stands mature, especially pine-dominated stands, and as fuels continue to amass in the area as part of the natural progression of forests.

On private lands in and around the Project Area, it is likely that development would continue in the form of additional homes and structures, both permanent and seasonal. Along with this increased development there would likely be a corresponding increase in the population of the area, both people living permanently in the WUI and those who use the land seasonally, such as hunters and other Forest users. As the population of the area increases, there would likely be an increased possibility of human-caused fires in and around the Project Area, which is the number one cause of wildfires on the HMNF. The increased opportunities for wildfire starts could result in damage not only to the public resources of the Project Area, but an increase in the damage to private property and structures, as well as an increased hazard to Forest users. There is the potential that seeing the fuels management activities taking place on public lands might spur private landowners to adopt similar practices on their property.

Air Quality

The Direct and Indirect Effects of Implementing Alternatives 1, 2, and 3

Alternative 1 would not drive the Project Area toward accomplishing the goals and objectives of this Project or the goals and objectives and the DFC outlined in the Forest Plan, particularly in regard to hazardous fuels treatments. The selection of Alternative 1 would result in the continued accumulation of hazardous fuels in the WUI, identified Communities at Risk (Federal Register 2001), and intermix areas which could result in increased risk from catastrophic wildfire. The

buildup of fuels under Alternative 1 may result in an increase in emissions if a wildfire does occur which could be both an increase in amount and duration of emissions and reduced visibility.

Under Alternatives 2 and 3, all prescribed burning would be in accordance with the Michigan Smoke Management Program (SMP). This SMP was developed with cooperation from the Forest Service, MDNR, Michigan Department of Environmental Quality (MDEQ 2002), and others to address concerns with Section VI, *Smoke Management Programs* of the EPA's "Interim Air Quality Policy on Wildland and Prescribed Fires." The purpose of the SMP is to mitigate nuisance smoke and public safety hazards, reduce smoke intrusions into populated areas, prevent deterioration of air quality, meet National Ambient Air Quality Standards, and address visibility impacts on Federal mandatory Class 1 areas.

Implementation of fire and fuels treatment utilizing prescribed fire would be in accordance with the provisions outlined in the SMP. The SMP was developed to minimize potential air quality impacts associated with prescribed fire.

Per Forest Service policy, and outlined in the SMP, there is a process for assessing and authorizing prescribed burns that includes the development of a burn plan for prescribed fire treatments. Along with other portions of the burn plan there is a section on smoke management and air quality. This section addresses how the prescribed burn would comply with local, State and Federal air quality regulations. It requires the burn plan to identify smoke sensitive areas including population centers, recreation areas, hospitals, schools and other restricted areas that may be impacted. The burn plan also estimates fuel loadings (tons/area) to estimate air quality impacts and identifies safety and contingency plans to address possible smoke intrusions into sensitive locations.

Per Forest Service policy and the SMP "daily monitoring of atmospheric conditions and weather forecasts are necessary to determine the impacts of large air masses and atmospheric disturbances on smoke dispersion." Mixing height, transport winds, and ventilation indices are produced as part of the daily fire weather planning forecasts prepared by the National Weather Service. Throughout much of the State atmospheric conditions are capable of acceptably dispersing prescribed fire smoke and smoke byproducts throughout much of the year. However, seasonal trends in atmospheric dispersion potential should be part of any burn plan for smoke management associated with fire use.

In the development of burn plans for prescribed fire treatments within the Bigelow-Newaygo Project Area burn plan writers would be required to follow a national interagency template which addresses many different elements. One of the required elements is to create a site-specific smoke management plan. This plan should evaluate potential impact areas, establish mitigation strategies and techniques to reduce smoke impacts, and develop contingency plans for adverse smoke impacts. Another element identifies the specific weather parameters under which prescribed fire treatments can be implemented to accomplish fire behavior, fuels and smoke management objectives. One item the burn plan writers can identify when developing the burn prescription is acceptable ventilation indexes (Table 3-43) to minimize smoke impacts on surrounding areas. The SMP outlines acceptable burn size, fuel types and distances from smoke receptors for burns based upon the dispersion category for the day.

Historically, most prescribed burns on the HMNF have had ignition operations complete within one burn period with minor smoke impacts the following days. Screening models such as the

SHRMC Simple Smoke Screening tool are available for the burn boss to use to determine where the smoke could travel to so that the burn boss may be able to determine and mitigate possible impacts. Other regional smoke dispersions systems such as BlueSky and HYSPLIT are available to estimate smoke emissions, possible trajectories and smoke dispersal on the day of a prescribed burn using the forecasted weather to evaluate smoke impacts.

Ventilation Index and Dispersion Categories Identified in the Michigan Smoke Management Program
Table 3-43

Ventilation Index	Dispersion Category
0 - 130	Poor
131 - 299	Fair
300 - 599	Good
600+	Excellent

Estimated Emissions Pre and Post Treatments Utilizing Consume Models
Table 3-44

	Jack Pine		Red Pine		Mixed Hardwood	
Emissions	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
PM	0.16	0.08	0.12	0.09	0.17	0.07
PM10	0.12	0.05	0.08	0.07	0.10	0.04
PM2.5	0.11	0.05	0.08	0.07	0.09	0.04
CO	0.90	0.43	0.66	0.53	0.72	0.30
CO2	14.58	6.00	11.69	8.41	15.91	6.42
CH4	0.04	0.02	0.03	0.03	0.03	0.01

For the Bigelow-Newaygo Project Area the computer software program Consume v3_0 was used to predict pollutant emissions based upon estimated fuel loadings, fuel moistures and other environmental factors. Table 3-44 illustrates the differences between emissions for an initial wildfire on the landscape and a second wildfire (post-treatment). There is a reduction in emissions in all vegetative communities sampled. While this is an estimate, the models show beneficial effects of the proposed treatments on the landscape with a reduction in emissions post-treatment. If a wildfire were to occur in similar areas post treatment during the modeled fuel conditions, the resulting emissions would be similar.

The Cumulative Effects of Implementing Alternatives 1, 2, and 3

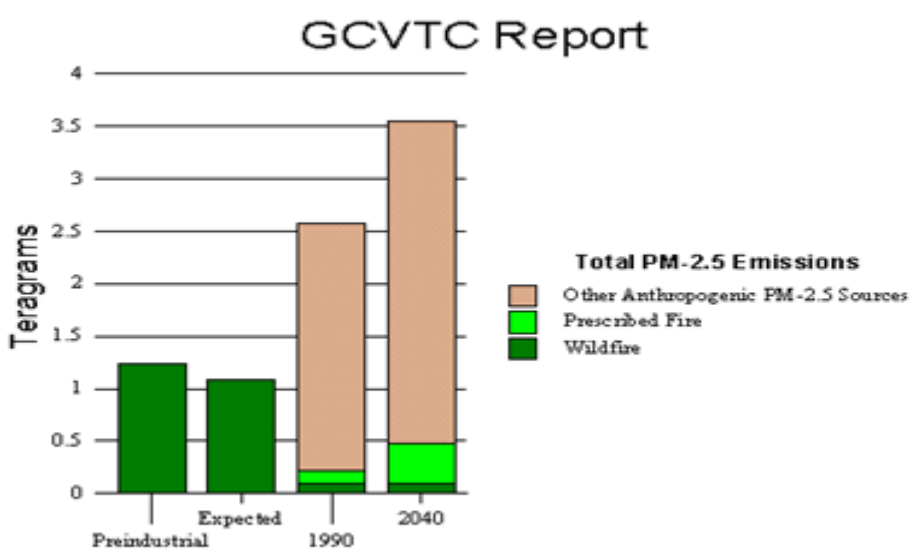
Alternative 1 would not drive the Project Area toward accomplishing the goals and objectives of this Project or the goals and objectives and the DFC outlined in the Forest Plan, particularly in regard to hazardous fuels treatments. The selection of Alternative 1 would result in the continued accumulation of hazardous fuels in the WUI, identified Communities at Risk (Federal Register 2001), and intermix areas which could result in increased risk from catastrophic wildfire. This alternative could also increase the threat to public and firefighter safety by permitting the increase in in the amount of forest fuels in the landscape.

The buildup of fuels under Alternative 1 may result in an increase in emissions if a wildfire does occur which could be both an increase in amount and duration.

When combined with past, present and reasonably foreseeable future actions Alternatives 2 and 3 would move the Project Area toward accomplishing the goals and objectives and the DFC outlined in this Project proposal and the Forest Plan, particularly in regard to fuels treatments, where Alternative 1 would not. Both alternatives would have a positive cumulative effect by reducing hazardous fuels in the WUI and intermix areas, and achieving fire-hazard reductions.

The cumulative effects of implementing treatments within the Project Area on both public and private lands would produce cumulative affects with regard to smoke production in the past, present and future landscape. However, as described in the SMP, "*The use of wildland fire presents the need to weigh the trade-offs associated with the ecological benefits of fire versus the impacts of a short term increase in emissions from current and accelerated burning programs. Part of the trade-off involves the careful consideration of and application of smoke management techniques to minimize the amount and/or impact of emissions while still meeting ecological needs. An example of this trade-off to be considered is the increased fuel consumption from a wildfire burning under severe meteorological conditions vs. the reduced fuel consumption of a prescribed fire ignited that might burn under moderate weather conditions*."

Figure 3-6



As mentioned in the Smoke Management section of this report, the production of smoke must be managed to the best of our abilities (ventilation index, wind direction, lighting technique, etc.) while striving to meet Forest Plan objectives and goals. However, National Inventories of Emissions show overall production of emissions from prescribed fire and wildfire is minimal when

compared to emissions from anthropogenic sources (Figure 3-6) (www.nifc.gov/smoke/smoke_emissions.html).

When combined with past, present and reasonably foreseeable future actions Alternatives 2 and 3 would continue the trend of reintroducing fire into fire-adapted ecosystems. The proposed actions are cumulative with opening creation, restoration, and maintenance; savanna restoration and maintenance; prescribed burning and timber harvesting. Alternatives 2 and 3 would have a positive effect on restoring natural fire regimes by maintaining disturbances in ecosystems that have adapted over time to periodic short-return interval disturbances (particularly fire). When combined with past, present and future activities these projects would provide short- and long-term positive contributions within the analysis area by increasing tree spacing, reducing fuels, reducing long-term emissions and reintroducing fire into the ecosystem.

Heritage Resources

Resource-Specific Information & Existing Condition

The primary heritage or cultural resources issue in this analysis is the protection and preservation of cultural resources and the assurance that significant cultural resources are not affected by the implementation of the Action Alternatives. The Action Alternatives consist of a Federal undertaking for which the Federal agency must take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register (16 U.S.C. 470f). If the undertaking leads to adverse effects, then these adverse effects need to be resolved through mitigation. The criteria for adverse effects is defined as when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register of Historic Places in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association (36 CFR Part 800.5(a)(1)). Historic properties and cultural resources can have values attributed to them other than the physical remains on the ground; however, the cultural resources identified within the Action Alternatives are limited to effects from ground disturbing actions. The Action Alternatives include ground disturbing activities contained within a specified project boundary. This project boundary or Project Area is identified in Section 106 of the National Historic Preservation Act as the Area of Potential Effect (APE). All previously known and newly identified cultural resources located within or immediately adjacent to the APE have been accounted for in the review of this proposed undertaking.

The analysis area for the cultural resources encompasses the boundaries of Forest Service management units designated as compartments 513, 517, 519, 520, 521, 522, 573, 576, 578, 582, 583, 585 and 586 of the BWC Ranger District. Any cultural resource that could be affected by management activities would be limited to this area.

The cultural resources cumulative effects analysis area includes all public and private lands, and waterways contained within and adjacent to the boundary of the Bigelow-Newaygo Project Area. Cumulative effects of project actions may affect one or more aspects of a particular historic property’s integrity. There are seven aspects consisting of 1) Location, 2) Design, 3) Setting, 4) Materials, 5) Workmanship, 6) Feeling, and 7) Association used to assess the integrity of historic properties (NPS 1990). The type of cultural resource and the specific effects of the undertaking in relation to that cultural resource, determines the extent of the cumulative effects analysis area.

Section 106 of the National Historic Preservation Act requires Federal agencies to take into account the effect of a project on any district, site, building, structure, or object that is included in, or eligible for inclusion in, the National Register of Historic Places (16 U.S.C. 470f). The Archeological Resources Protection Act provides the criteria and means for issuing permits to an applicant for excavation or removal of any archaeological resources located on public lands or Indian lands (16 U.S.C. 470cc(a)) and defines prohibited acts and criminal penalties to include unauthorized excavation, removal, damage, alteration or defacement of archaeological resources (16 U.S.C. 470ee; 16 U.S.C. 470ee(a)) and trafficking in archaeological resources (16 U.S.C. 470ee(b)). The Federal government has trust responsibilities to Tribes under a government-to-government relationship to ensure that Tribal rights are protected. Consultation with Tribes helps ensure that these trust responsibilities are met. The HMNF consulted with potentially affected Tribes and no tribal concerns were identified for this Project. A cultural resource survey was conducted in the Project Area, in accordance with the HMNF's cultural resource guidelines.

Archaeological resources are the physical remains left by people who occupied or visited the Forest in prehistoric or historic times. These are fragile, non-renewable resources. They include, but are not limited to prehistoric and historic Native American settlements, logging industry related resources, Euro-American pioneer farms or homesteads, and former villages and towns. The significance of individual sites is based on their relationship to important events, peoples or styles, and their ability to provide additional scientific information about the prehistory or history of the area.

The Bigelow-Newaygo Project Area has been a focus of human activities for the last 11,000 years. Until the arrival of the first Europeans in Michigan, various Native American peoples periodically occupied what is now Newaygo County. Paleo Indian projectile points have been found north of the Muskegon River (Prahl 1966). Between 2000 B.C. and about 500 B.C., Indians of the Archaic period hunted deer and fished in the summer (Fitting 1970). By about 100 B.C., the Hopewell Indians lived in what is now Newaygo County. The Hopewell culture probably extended as far north as the Muskegon River. Artifacts from this period have been found in numerous mounds on the river bluffs between Newaygo and Croton, where the Hopewell buried artifacts with their deceased (Prahl 1966). The Mallon Mounds near Brooks Lake and other mounds date from the Woodland Period (700-1000 A.D.). Natives of this period were probably predecessors of the Ottawa, who made contact with the first Europeans (Prahl 1966).

The first Europeans to navigate the Muskegon River were French trappers who traded with the natives well before Euro-American settlement occurred. The earliest permanent trading post on the Muskegon River dates to about 1834. Another trading post was established at Old Woman's Bend, 2 miles below the present city of Newaygo (Spooner 1977). European settlement in the area began with lumbering. After the Treaty of 1836, speculators came in from Chicago to establish claims over vast timber resources, establishing squatter's rights at the river mouths to run their water powered sawmills. Lumbering was the chief industry during the 19th century and the County was also well enriched with sources of water power (Jochim 1893). It is believed that more logs have floated down the Muskegon River than any other river in the world (Spooner and Wantz 1987). As the timber along the river was depleted, roads and railroads were built to transport logs. In about 50 years, the forest and soils were forever changed as a result of clearcutting, forest fires, and farming. The crops in the areas of cleared forest were used to feed the growing population in the lumbering camps.

Several hundred acres were cultivated during the mid-1800s in the area of remnant prairie in what is now Big Prairie Township. The soil in this area was a Sparta sand that had a 12-18 foot layer of mixed sand and organic material. It was devoid of trees and could be easily farmed. The fertility of the soil was fair, and good crops were produced during the first few years. After the removal of the plant cover and depletion of plant nutrients, however, the soil was dry and subject to soil blowing. In some areas, 2-3 feet of soil was eroded. As a result, the largest area of desert east of the Mississippi River was created (Matson 1977; Evans 1977). This area became a tourist attraction (Matson 1977; Evans 1977) until it was reforested. Pine plantations now cover much of the area (USDA 1951).

The Project Area has had at least 43 previous cultural resource surveys conducted within the APE. These previous surveys were conducted for land exchanges, wildlife habitat, prescribed burning, savanna restoration, timber sales, and road easement special use permits. Thirty-two cultural resources were identified within the APE during these surveys. During the current survey, cultural resource personnel located 14 new cultural resource sites within the APE. Of the 43 cultural resources identified all but three are historic sites, and include historic cemeteries, depressions, homesteads, foundations, dumps, camps and various other historic sites. None of these sites have been evaluated for National Register of Historic Places eligibility; however, all sites are assumed to be eligible at this time and will be protected to preserve their current state of condition until such an evaluation is made.

The Direct and Indirect Effects of Implementing Alternative 1

Alternative 1 will maintain the status quo of the direct and indirect effects to cultural resources in the Project Area. Direct impacts to cultural resources from this alternative may include the continuation of hazardous fuel loading and ground disturbance and/or obliteration from unimpeded dispersed recreational access. By not reducing the hazardous fuel loads, cultural resource structural features and artifacts may be damaged from unchecked vegetative growth and dead and down vegetation.

The potential for restricting public vehicular access and dispersed recreational activities by closing and obliterating select Forest Service and user-created roads will not occur. By maintaining the unrestricted access through Alternative 1, the ground disturbance impacts from dispersed recreation, specifically camping, ORVs, and refuse dumping, will continually increase on known heritage resources and spread from a localized containment area to other areas of that resource, as well as to adjacent known and unknown heritage resources.

The indirect effects of this alternative may include benign neglect to heritage resources, soil erosion from unrestricted dispersed recreation and changes in the visual integrity of both known and unknown heritage resources.

The Cumulative Effects of Implementing Alternative 1

Alternative 1 would perpetuate the existing condition, which allows for the continued buildup of hazardous fuels and soil erosion from unrestricted dispersed recreational activities.

Cumulative effects of hazardous fuels consist of unhindered vegetative build up (both live and dead and down) on and around heritage resources. This cumulative buildup of fuels produces a greater chance for catastrophic wildfire that could potentially obliterate the cultural resource or at

least remove the potential for yielding specific data that addresses important research questions. If this were to occur, the cultural resource would lose its integrity and significance.

Dispersed recreational activities usually (but not always) combine with time and repetitious use to create soil erosion. Soil erosion from dispersed recreation can be both site-specific and widespread. Dispersed recreational activities can produce rutting, down cutting, large soil displacement/removal from creation of hunting blinds and garbage disposal, as well as ORV damage to slopes, wetlands and cultural features. Ground disturbance directly on or adjacent to the cultural resource usually results in severe damage or complete obliteration of that cultural resource, while ground disturbance within the view shed of the cultural resource may affect the site's visual integrity.

The Direct and Indirect Effects of Implementing Alternatives 2 and 3

The direct and indirect effects of Alternatives 2 and 3 would be the same for either alternative. Direct effects of the proposed actions would be dependent upon the type of treatment conducted within a specific area within the APE.

Red pine and jack pine thinning potential effects consist of ground disturbance from mechanical vegetative removal, greater exposure and access to heritage resources by public and accidental damage to cultural features. Depths of disturbance would generally range from 1 to 5 inches. Indirect effects consist of increased soil erosion potential.

NNIP treatment potential effects consist of potential ground disturbance activities, greater exposure and access to heritage resources by the public and accidental damage to cultural features. Indirect effects consist of increased soil erosion potential.

Prescribed fire broadcast burning potential effects consist of ground disturbance from creation of tractor-plow fire control lines and broadcast burning. Depths of disturbance would generally range from 1 inch to 36 inches. Indirect effects consist of increased soil erosion potential.

Clearcutting potential effects consist of ground disturbance from mechanical vegetative removal. Depths of disturbance would vary with the type of activities conducted, but would generally range from 1 inch to 36 inches.
Opening creation potential effects consist of ground disturbance from mechanical vegetative removal, soil compaction and/or tire churning from heavy equipment, creation of fire control lines and dozer pushes. Depths of disturbance would generally range from 1 inch to 36 inches. Indirect effects consist of increased soil erosion potential.

Opening maintenance potential effects consist of ground disturbance from creation of tractor-plow fire control lines, broadcast burning, and damage to features from mowers/brush hogs. Depths of disturbance would generally range from 1 inch to 36 inches. Indirect effects consist of increased soil erosion potential.

Fire control line creation potential effects consist of ground disturbance from mechanical vegetative removal, creation of tractor-plow fire control lines, broadcast burning. Depths of disturbance would vary with the type of activities conducted, but would generally range from 1 inch to 36 inches.

The Cumulative Effects of Implementing Alternatives 2 and 3

When considered with past, present and reasonably foreseeable future land management actions, Alternatives 2 and 3 may have either a beneficial or detrimental cumulative effect on heritage resources.

Cumulative effects would occur under Alternatives 2 and 3; however, these alternatives would provide for the best means to mitigate these effects to heritage resources. The cumulative effects in the Bigelow-Newaygo Project Area could be both beneficial and detrimental. Primary causes for cumulative effects are hazardous fuels buildup and vegetative treatments, with soil erosion as a secondary cause.

Effects from vegetative treatments include ground disturbance activities and potential visual disturbances (setting) to heritage resources, accidental destruction of cultural features from mechanical equipment and hand tools, and accidental damage to unknown cultural resources. Cultural resource site-specific mitigation measures are designed and used to preserve the cultural resource from accidental damage during Federal treatment actions. Without these specific mitigations, the subsequent cumulative effects would be the continuous damage or destruction of the heritage resources, which would eliminate the integrity and significance of each cultural resource until potentially none remained.

Visual setting (integrity) often reflects the basic physical conditions that can be either natural or manmade (NPS 1990). The visual integrity of a cultural resource may be affected depending on the proposed type of fuels or land management treatment. The extent of visual integrity may expand from a few hundred meters to a 3-mile or greater radius of the cultural resource.

Soil erosion may occur from land management activities and unrestricted ground disturbing dispersed recreational activities. Soil erosion may be caused directly or indirectly from land management actions. This erosion may take the form of poor drainage that causes rutting, rilling, sheet wash, down cutting or other soil displacement that buries, exposes or causes direct damage to cultural features and artifacts. Ground disturbance directly on the cultural resource, adjacent to the cultural resource, or upslope/downslope of the cultural resource may create inadvertent soil erosion. The cumulative effects of soil erosion, if not mitigated, would lead to irreversible damage and destruction of cultural resources throughout the Muskegon River and tributaries watershed and lands held within and adjacent to the undertaking's boundary.

Beneficial cumulative effects include maintaining vegetative debris at acceptable and manageable levels that would reduce or remove damage to cultural resource features and artifacts. It would also reduce or remove the level of damage or loss of specific data and integrity by diminishing the potential for catastrophic wildfire. Detrimental cumulative effects include creating greater public visibility and access to the heritage resources. With the possible creation of new roads, ingress and egress for project actions or establishment of fire control lines, the immediate effect is greater access to previously inaccessible or restricted portions of the APE with motorized vehicles. Long term effects of these actions allow for ground disturbance impacts from dispersed recreation to continually increase and spread from a localized containment area into the previously unaffected portions of the APE. Where this occurs, the cumulative effects of unimpeded dispersed recreation would remove the potential for yielding specific data that addresses important research questions. As a result, the cultural resource would lose its integrity and significance.

Direct effects to heritage resources are those that would cause immediate disturbance or desecration of an archaeological site, such as bulldozing a site in the road building process. These actions could cause permanent loss of information and affect the site's eligibility of nomination to the National Register of Historic Properties. Indirect effects could also result from management activities. Examples are the disturbance of a site due to windthrow of trees as a result of harvesting an adjacent stand or the increased visibility of a site (opening a stand allowing easy access by road or trail) thus increasing the potential for vandalism or ORV damage.

The known cultural resource sites would be protected as recommended by the HMNF's archaeologist, and in accordance with State Historic Preservation Office guidelines. Mitigation measures used to avoid disturbance to archaeological sites would be applied to Alternatives 2 and 3. These cultural resource mitigation measures are incorporated into the Treatment Unit Cards (see Planning Record). If additional cultural resource sites are found during project implementation, project work would cease, a cultural resource professional would be consulted, and adequate protection measures applied.

If these recommendations are implemented, any and all heritage resources within the Project Area will have been documented, protected, and/or removed from the APE. No cumulative effects to heritage resources are expected from these actions.

Recreation

Resource-Specific Information & Affected Environment

Area of Analysis

The spatial boundary for direct and indirect effects is the Project Area which includes NFS lands, private lands, lands managed by other government units (State, County, and Townships), and other land managers (Consumers Energy and Michigan Nature Association). This boundary was identified since all treatments that could affect persons using this geographical area or change the recreational opportunities of the area would be limited to the Project Area. The temporal boundary will be 5 years after the treatments are completed because that allows enough time for treatments to blend and become part of the landscape and for changes to become less noticeable to recreationists.

The spatial boundary for cumulative effects is the Project Area for the reasons described above. The temporal boundary will be 5 years prior to this decision to 10 years beyond. This is the approximate amount of time that past, present, and reasonably foreseeable projects could overlap with the Bigelow-Newaygo Project activities.

Affected Environment

The Project Area covers a large geographic area that encompasses six townships in three counties. The communities of White Cloud and Newaygo are adjacent to the project and the community of Croton is within the Project Area. Private lands and associated development, both residential and commercial, is the dominant feature in the landscape. NFS lands are isolated blocks, some as small as 10 acres, that have been heavily influenced by activities occurring on the surrounding private lands. Trash dumping; user-created trails, both motorized and non-motorized; firewood

cutting; deer blinds; and minor encroachments can be found on many of the Federal tracts in the Project Area.

Recreational opportunities and activities vary depending on your location north or south of State Highway M-82. North of the highway there are a number of recreation sites on Hardy and Croton Ponds, including Newaygo State Park, Hardy Dam Marina, and Sandy Beach Campground, that provide opportunities for water-based activities such as jet skiing, fishing, and camping, in a highly developed setting. Woods and Waters and Leisure Time are both privately-owned RV resorts that provide seasonal recreational living adjacent to Federal land. Twinwood Lake is the only federally-managed recreation site in the Project Area; its setting would be characterized as rustic. A fee to use the boat launch or to camp is required. Bigelow, Coolbaugh, and Penoyer Creeks flow through the northern part of the Project Area and provide opportunities to fish for trout, salmon and steelhead.

Hiking is available on the North Country National Scenic Trail (NCT) and is the only federally-designated trail in the Project Area. There is a connector trail from the NCT to the Coolbaugh Nature Preserve, owned and managed by Brooks Township, where there are trails for hiking and horseback riding. A non-motorized trail for hiking and biking around the Hardy Pond is in the planning phase that when completed in 2017 (estimated) (McTaggart 2014) will be 30 miles long. There are no formally designated trails for horseback riding on NFS lands in the Project Area, but riding in this part of the Project Area is common and user-created trails parallel existing County and Forest Roads and cross many of the Federal parcels. Riding in the Newaygo Prairies RNA and on the NCT, which is prohibited, is occurring. Illegal ORV use is occurring on private and NFS lands in sensitive habitats in an area between Basswood and the railroad and in the powerline corridor that parallels Pine Avenue.

The southern part of the Project Area is a large, contiguous block of NFS lands with private inholdings easily accessed from M-82 and a number of year-round and seasonal County roads as well as Forest Service Level 2 roads. It is bounded on the east by Bills and Pettit Lakes and the west by Brooks and Hess Lakes, all having heavily developed shorelines. Utility corridors transect the Project Area north and south (Consumer's Energy) and east to west (DTE Energy) providing additional avenues for motorized access for driving for pleasure, trash dumping, illegal ORV use, and trespass.

There are no developed recreation facilities or designated trails on NFS lands in this part of the Project Area. Recreation activities include: hunting; driving for pleasure; ORV riding on County roads, utility corridors, and user-created trails; camping, including recreational and living on the National Forest during clement weather; hiking; and gathering forest products. The State of Michigan maintains four public access sites on the Muskegon River popular with anglers, canoers and tubers and on Bills and Brooks Lakes. There is a private RV campground on Hess Lake.

There are no streams or lakes in this part of the Project Area on NFS lands. There are some remnant coastal plain marshes scattered throughout the area with user-created roads/trails that have been closed in the past and are now breached.

There are no designated motorized trails in the Project Area; however, the majority of Newaygo County Roads are open to ORVs and snowmobiles. Opportunities to ride on motorized trails within the vicinity of the Project Area include: Trail 3, a snowmobile trail that begins at the Newaygo County Sports Park located on the western side of the Project Area and the M-20

Motorsport Trail, that includes a portion of the 1,200 mile Michigan Cross Country Cycle Trail, located just northwest of White Cloud.

Past, Present, and Reasonably Foreseeable Actions

Population

From 2000 to 2010 regional growth for the Midwest was 3.9% as compared to the South and West that had population growth at 14.3% and 13.8%, respectively. Michigan was the only State to have a decrease in population from 2000 to 2010, at -0.6% (US Census 2011). In contrast, Newaygo County's population had a slight increase, from 47,874 to 48,460 people during the last census. However, the annual estimate of the resident population shows that there has been a slight decrease from 48,460 to 48,001 people (2010 and 2013, respectively) (US Census 2014). Of the six Townships within the Project Area, four have had an increase in population from 2000 to 2010: Aetna by 12%; Big Prairie by 4%; Croton by 6%; and Reynolds by 24%, and two Townships have had a decrease: Brooks by 5% and Everett at 6% (US Census 2011). Over the next decade the population of Newaygo County is expected to remain unchanged or increase only slightly based on data from the last two censuses and annual population estimates.

Land Management

Land management activities such as harvesting, reconstruction and brushing of utility corridors, and activities typical of private and commercial lands are common occurrences in the rural setting of the Project Area and are generally accepted by residents and visitors. However, there is an expectation by some that the Federal lands will remain unchanged.

The small size and isolated nature of the Federal lands has meant an emphasis on dispersed versus developed recreation opportunities by the Forest Service. Other public land managers and the private sector have filled this niche providing a wide variety of developed recreation opportunities in the Project Area. This mix of dispersed and developed recreation opportunities is not expected to change much over the next 10 years; the expected timeframe for the implementation of the Bigelow-Newaygo Project.

The Direct and Indirect Effects of Implementing Alternative 1

Under Alternative 1 recreation management activities in the Project Area would continue including maintenance of the NCT and Twinwood Lake Recreation Area. Rules and policies as they relate to camping, motor vehicle use including ORVs and snowmobiles, horseback riding, mountain biking, hiking, and hunting and fishing on NFS lands would continue to apply and be enforced.

Resource and private property impacts from dumping, trespass, and illegal ORV use would continue because there would be no closure of ORV play areas, utility corridors, and user-created trails. Improvements to the County and Forest Service road system would not occur which, over time, could limit access to public lands for recreational activities, such as driving for pleasure, wildlife viewing and hunting, as sand roads further degrade. Upgrading road-stream crossings and in-stream habitat improvements to enhance water quality and increase fishing opportunities would not occur.

Short-term displacement from recreational activities of area users and adjacent landowners during timber management, prescribed burning, savanna and prairie restoration, and NNIP activities would not occur. No habitat management activities would occur; therefore, opportunities for viewing wildlife, gathering forest products, and hunting would remain unchanged. The visual quality of the area would not be changed or affected by management activities, i.e. forested to a more open appearance; however, the rural setting and character of the Project Area in which human activities and their impacts, both positive and negative, would continue to be evident.

Treatment of NNIP to reduce harmful infestations of species that compete with native plants found in savanna and prairie habitats would not occur reducing opportunities for viewing and exploring these unique habitats.

The Cumulative Effects of Implementing Alternative 1

There would be no cumulative effects under Alternative 1.

The Direct and Indirect Effects of Implementing Alternative 2

Changes to the landscape would likely be less acceptable to those living in the Project Area, and in particular those living adjacent to an area proposed for management, than those who visit or are just passing through. Small, isolated blocks of public land, which is typical in the Project Area, often are treated and cared for like an extension of a private landowner's backyard.

Residents and visitors that use the HMNF for hunting, hiking, horseback riding and other recreational pursuits may find their access limited and could be displaced during active management activities such as, logging, savanna/prairie creation, and prescribed burning. This displacement would be short-term, 1-2 weeks, in areas that were burned and longer term in areas of habitat restoration where it might be necessary to limit certain uses or access until a site is restored. Harvest units where slash and regeneration make an area less useable or desirable for activities such as hiking, hunting, and camping would have the longest period of displacement, which could be decades depending on the activity.

Other direct effects of these management activities include an increase in noise and dust from heavy equipment, smoke during burning operations, and an increase in traffic on area roads. These effects would be short-term and would be limited to periods of active management. Indirect effects of the timber management, prescribed burning, savanna/prairie creation, and NNIP treatments include increased opportunities for wildlife and rare plant viewing and gathering forest products, improved hunting, an increase in the number of dispersed campsites (log landings), and the potential for increased illegal ORV use and horseback riding in savanna and prairie areas and on skid trails.

Management activities along the NCT would directly impact hikers during logging, restoration, and burning operations. Impacts include the sight and sound of equipment, the smell of smoke and the presence of blackened vegetation from prescribed burns, and the presence of slash along the trail. These impacts would be mitigated with safety signing and notices posted at trailheads and the use of buffers and slash treatment zones along the trail. Indirect benefits for some users include more open views along the trail and the opportunity to view rare plants and wildlife in savanna and prairie areas. Those who prefer to hike in a closed-canopy forest may find the changes along the trail corridor unacceptable.

The in-stream structures, riparian plantings, and road stream crossing upgrades would result in improved water quality and habitat in the Bigelow Creek watershed directly benefitting those whose recreation activities include fishing and camping. Road stream crossing improvements would likely result in delays for those traveling in the area from detours during construction; however, these would be short-term.

Under the Proposed Action, improvement of approximately 8 miles of County and Forest roads are proposed. These improvements, including widening and gravel placement, would directly benefit those who use the road system to access Federal lands for recreation, especially those who enjoy viewing scenery and driving for pleasure. Closures or limited access during reconstruction may be necessary and could create delays and minor inconveniences for the public.

In addition to the road system upgrades, closures of approximately 4 miles of roads that are redundant or contributing to resource damage would occur. These closures would reduce the opportunities for legal motorized recreation activities such as driving for pleasure, viewing scenery, and access for hunting and, depending on the methods used to close a road, they could affect non-motorized activities such as hiking and horseback riding. However, the closures would address the issues of resource impacts from illegal ORV use, dumping, and trespass on both public and private lands. The combination of road improvements and closures would result in a safer road system that continues to provide access to public lands for recreational activities.

Repair of resource damage which includes closing to motor vehicles an ORV play area along Basswood Avenue, utility corridors, and areas previously closed and breached throughout the Project Area would affect those who have been illegally riding and damaging NFS lands and private property. These users could chose to ride in areas that are open, i.e. Newaygo County roads or designated trail systems adjacent to the Project Area or move to new areas such as newly created savanna and prairies or private property. To prevent breaches and impacts to new areas, the closures would be followed up with enforcement. Over time, the aesthetics of the area would improve as disturbed areas recover and vegetate.

The Direct and Indirect Effects of Implementing Alternative 3

Alternative 3 proposes less savanna creation, opening restoration, prescribed burning and road closures than the Proposed Action. Although fewer areas would be managed the direct and indirect effects for recreation wouldn’t differ between Alternatives 2 and 3. However, the time period in which the management activities and associated effects would occur would likely be shorter under Alternative 3.

The Cumulative Effects of Implementing Alternatives 2 and 3

Considering the past, present, and reasonably foreseeable future actions (discussed above) which includes the actions proposed in Alternatives 2 and 3, with respect to cumulative effects to the recreation opportunities and a user’s experiences none are expected.

Transportation

Existing Condition and Resource-Specific Information

Classification

In discussing the management of the transportation system within the Project Area, the area of analysis for the transportation system does not include the portion of Compartment 517 that is in MA 9.2, or Compartments 578, 582, and 586. This is because no transportation related activities would occur in these areas. The Interdisciplinary Team (IDT) has categorized the roads in the Project Area as of 2014: 1) County roads, and 2) Forest Service roads that are on the MVUM. For this project, County roads are those roads that are claimed, maintained, and under the jurisdiction of Newaygo County. The management of these roads is carried out by the Newaygo County Road Commission. Some of these roads are maintained throughout the year, and some are maintained seasonally (not being plowed during the winter months). MVUM roads are under the jurisdiction of the Forest Service, are wholly or partially within or adjacent to NFS lands and have been previously designated as needed for motor vehicle access. Typically, these roads have been created by the Forest Service, are seasonally open, and receive minimal to no maintenance. Forest Service roads are utilized during the spring, summer, and fall by recreationists and local traffic. These roads are not plowed in the winter.

Road Density

The common unit of measure for the level of roads that are present on a specified land area is referred to as the road density. This is typically expressed as the miles of road per square mile (mi/mi^2). This measure allows comparisons to be made between the amount of roads that are present in a given MA and of the maximum average amount in the Forest Plan guidelines. This measure is useful at analyzing roads at a coarse and fine scale.

County roads within the Project Area have been identified by using Forest Service spatial data. To avoid the double counting of these roads (in future projects adjacent to this Project Area), the IDT has used ½ of the total value of County-claimed roads for the areas where the County roads serve as a Project Area boundary. The total value of County-claimed roads has been used for areas that are completely within the Project Area.
The Forest Service roads within the Project Area have been identified through the MVUM. To avoid the double counting of these roads in future road density calculations, the IDT has used ½ of the total value of classified roads for the areas where they serve as Project Area or ownership boundaries.

For this analysis, the road densities have been calculated two ways. First, only those County and Forest Service roads on the MVUM or adjacent to the Project Area boundary were counted; boundary roads were counted at ½ value to avoid double counting. This calculation only considers roads on NFS lands and this data is displayed in the first column of Table 3-45. Because the effects relative to the presence of roads is not constrained by jurisdiction or ownership, a second calculation of road density of all roads for all ownerships within the Project Area was completed. This information is shown in column 2 of Table 3-45.

The entire Project Area consists of approximately 24,000 acres or 37.5 square miles. Of this, approximately 6,000 acres or 9.5 square miles are NFS lands.

Project Area Road Data
Table 3-45

Type	All Roads on NFS Lands within the Project Area (Includes County roads adjacent to NFS lands and Forest roads shown on the MVUM)[1]			All Roads on All Ownerships within the Project Area (Includes County and Forest roads)[2]		
All Management Areas within the Project Area						
Road Mileage	23.7			82.2		
Area (acres)	6,091			23,668		
Area (mi^2)	9.5			37.0		
Current Road Density (mi/mi^2)	2.5			2.2		
Management Area 4.4 - Rural						
Desired Road Density for All Roads on All Ownership in This Management Area: 0-3 mi/mi^2						
Existing Condition:						
Type	**All Roads on FS Lands within the Project Area** (Includes County roads adjacent to NFS lands and Forest roads shown on the MVUM)[1]			**All Roads on All Ownerships within the Project Area** (Includes County and Forest roads)[2]		
Road Mileage	20.8			77.9		
Area (acres)	5,442			22,920		
Area (mi^2)	8.5			35.8		
Percent of Total Area	89.3			96.8		
Current Road Density (mi/mi^2)	2.4			2.2		
	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 1**	**Alternative 2**	**Alternative 3**
Total Miles of Road Left Open	20.8	16.5	17.6	77.6	73.6	74.7
Forest MVUM Roads	6.0	2.0	3.1	6.0	2.0	3.1
County Roads	14.5[3]	14.5[3]	14.5[3]	71.6	71.6	71.6
Final Road Density	2.4	2.0	2.1	2.2	2.1	2.1
Management Area 8.2 - Research Natural Area						

Desired Road Density for All Roads on All Ownership in This Management Area: Not Applicable; No New Roads Would Be Established						
Existing Condition:						
Type	**All Roads on NFS Lands within the Project Area** (Includes County roads adjacent to NFS lands and Forest roads shown on the MVUM)[1]			**All Roads on All Ownerships within the Project Area** (Includes County and Forest roads)[2]		
Road Mileage	0.8			Not Applicable		
Area (acres)	177			Not Applicable		
Area (mi^2)	0.3			Not Applicable		
Percent of Total Area	2.9			0.7		
Current Road Density (mi/mi^2)	2.8			Not Applicable		
	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 1**	**Alternative 2**	**Alternative 3**
Total Miles of Road Left Open	0.8	0.8	0.8	NA	NA	NA
Forest MVUM Roads	0.7	0.7	0.7	NA	NA	NA
County Roads	0.1[3]	0.1[3]	0.1[3]	NA	NA	NA
Final Road Density	2.8	2.8	2.8	NA	NA	NA
Management Area 8.3 - Experimental Forest						
Desired Road Density for All Roads on All Ownership in This Management Area: Not Applicable						
Existing Condition:						
Type	**All Roads on NFS Lands within the Project Area** (Includes County roads adjacent to NFS lands and Forest roads shown on the MVUM)[1]			**All Roads on All Ownerships within the Project Area** (Includes County and Forest roads)[2]		
Road Mileage	0.9			Not Applicable		
Area (acres)	272			Not Applicable		
Area (mi^2)	0.4			Not Applicable		
Percent of Total Area	4.5			1.1		
Current Road Density (mi/mi^2)	2.9			Not Applicable		

	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3
Total Miles of Road Left Open	1.4	1.4	1.4	NA	NA	NA
Forest MVUM Roads	0.7	0.7	0.7	NA	NA	NA
County Roads	0.7[3]	0.7[3]	0.7[3]	NA	NA	NA
Final Road Density	3.4	3.4	3.4	NA	NA	NA
Management Area 8.4 - Special Area						
Desired Road Density for All Roads on All Ownership in This Management Area: 0-1 mi/mi^2						
Existing Condition:						
Type	**All Roads on NFS Lands within the Project Area** (Includes County roads adjacent to NFS lands and Forest roads shown on the MVUM)[1]			**All Roads on All Ownerships within the Project Area** (Includes County and Forest roads)[2]		
Road Mileage	0.9			Not Applicable		
Area (acres)	73			Not Applicable		
Area (mi^2)	0.1			Not Applicable		
Current Road Density (mi/mi^2)	7.9			Not Applicable		
	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 1**	**Alternative 2**	**Alternative 3**
Total Miles of Road Left Open	0.9	0.9	0.9	NA	NA	NA
Forest MVUM Roads	0.5	0.0	0.0	NA	NA	NA
County Roads	0.4[3]	0.4[3]	0.4[3]	NA	NA	NA
Final Road Density	7.9	3.3	3.3	NA	NA	NA

[1]*Roads which serve as Project Area or ownership boundaries are multiplied by 0.5 to avoid duplicative counting.*
[2]*County roads which are adjacent on only one side of the road or which serve as Project Area boundaries are multiplied by 0.5 to avoid duplicative counting.*
[3]*Does not include the estimated roads on private land and includes only those County roads which are adjacent to or on NFS lands.*

Relating Transportation System Management to the Forest Plan

The HMNF is divided into different MAs, with each area having Standards and Guidelines that apply to the management of the transportation system (USDA 2012c). The MAs for this project

are 4.4 (Rural), 8.2 (Research Natural Area), 8.3 (Experimental Forest), and 8.4 (Special Area). Table 3-46 shows the desired road densities for these MAs.

Desired Forest Plan Road Densities by Management Area
Table 3-46

Desired Road Density (mi/mi^2)	Applicable Management Area
0-3 Miles	4.4
Not Applicable	8.2[1]
Not Applicable	8.3[1]
0-1 Miles	8.4[2]

[1]*No average miles are listed for MAs 8.2 and 8.3.*
[2]*Newaygo Prairie Special Area does not have a defined road density therefore the default would be the same as other MA 8.4.*

The analysis area for direct and indirect effects for transportation includes Forest Service owned and non-Forest Service managed lands within the Project Area boundary. The analysis area for cumulative effects for transportation includes Forest Service compartments directly adjacent to the Project Area as well as State and private lands within 5 miles of the Project Area boundary. This area would include all roads found directly in the Project Area and also those roads that would be utilized for management activities including vehicle activity associated with timber sales and prescribed burning activities.

The Project Area totals approximately 23,688 acres. Approximately 6,091 acres (25% of total) are NFS lands, and the remaining acres, approximately 17,597 acres (75% of total), are in private or other ownership. This is the equivalent to approximately 37 square miles. Within the Project Area are MA 4.4, MA 8.2, MA 8.3, and MA 8.4. See Table 3-45 for breakdown of road miles by MA.

The management direction for the transportation system in MA 4.4 is a maximum of 3 miles of road per square mile, MAs 8.2 and 8.3 have no guidelines, and MA 8.4 is a maximum of 0-1 miles per square mile (USDA 2012C). There are approximately 82 miles of roads open in the Project Area on all ownerships according to the HMNF's GIS database. This equates to approximately 2.2 miles of road per square mile. On Forest Service ownership, the road density per square mile is approximately 2.5 miles per square mile. Current road density within Forest Service ownership is summarized in Table 3-47.

The average of 2.4 miles of road per square mile is within the maximum amount allowable of 3 miles per square mile set forth in the Forest Plan for MA 4.4. However, within MA 8.4 the road density is extremely high due to a combination of County roads surrounding the area and a Forest Service road going through the area. Due to the institution of the Travel Management Rule for the HMNF, the transportation system was analyzed in detail. As a result of this roads analysis, there is a wide variety of activities prescribed for the transportation system of the Project Area. The majority of Forest Service roads now found in the Project Area are not required to complete the harvesting activities due to the extensive network of County roads. The roads that are scheduled to be closed are those that the roads analysis found to be in an area of occupied KBB habitat (0.1 mile), in a Special Area (0.5 mile), or serve a purpose already filled by another road (3.3 miles).

Road management effects both Forest management and public use of an area, and influences resource damage and protection. Road construction or reconstruction is designed to provide long-

term access to an area at the minimum level necessary to meet resource and protection objectives. Design standards, seasonal restrictions, and road closures are all opportunities to influence the use of an area.

Road Density by Management Area
Table 3-47

Management Area	Acres	Area (mi^2)	Road Density (mi/mi^2)
4.4	5,571.0	8.5	2.4
8.2	176.8	0.3	2.8
8.3	271.6	0.4	3.4
8.4	72.5	0.1	7.9

The Direct and Indirect Effects of Implementing Alternative 1

There would be no changes made to the roads in the Project Area (Table 3-48). All NFS roads that are currently open would remain open. All NFS roads that are currently closed would remain closed. The open roads would continue to be minimally maintained. The NFS roads would be subject to closure at any time in accordance with the Forest Plan and the Travel Management Rule.

The direct effects of taking no action would be that the public would continue to be able to utilize the current roads throughout the Project Area. People that use the Project Area for recreation or access to homes would experience no displacement or loss of access. As population trends increase around the Project Area, and use increases within the Project Area, the roads would receive heavier use. This use may lead to more erosion and resource damage on the minimally maintained NFS roads. Additional user created roads within the Project Area would likely be created, due to the increase in use.

The Cumulative Effects of Implementing Alternative 1

Historically, the transportation system throughout the Project Area was used mainly for logging and transporting local people and agricultural commodities. Scattered throughout the Project Area are old railroad grades. These old railroad grades were used primarily for extracting timber from the area. As the land was cleared system. Since that time, the land has converted back to forested land. The Forest Service and converted to agricultural land, some of the railroad grades were converted into the current road has used some of the existing roads and built needed roads in the area for modern day logging operations. Some of these roads have remained open after harvesting and others have been closed.

Proposed Road Activity by Length and Cost for All Alternatives
Table 3-48

Road Activity	Alternative 1		Alternative 2		Alternative 3	
	Length	Cost	Length	Cost	Length	Cost
Construction - FS Level 1[1]	NA	NA	0.4	$8,000	0.4	$8,000
Construction - FS Level 2[2]	NA	NA	0.6	$20,000	0.6	$20,000
Reconstruction - FS Level 1	NA	NA	1.3	$15,000	1.3	$15,000
Reconstruction - FS Level 2	NA	NA	2.4	$67,000	2.4	$67,000
Total Forest Road Construction / Reconstruction	NA	NA	4.7	$110,000	4.7	$110,000
Total County Road Reconstruction	NA	NA	2.5	$67,000	2.5	$67,000
Total Road Construction / Reconstruction	NA	NA	7.2	$177,000	7.2	$177,000
Closure - FS Level 2[3]	NA	NA	3.9	$15,000	2.8	$11,000
Closure - County[4]	NA	NA	0.0	NA	NA	NA
Total Road Closure	NA	NA	3.9	$15,000	2.8	$11,000

[1]*Level 1 roads are for Forest Service use only.*
[2]*Level 2 roads are open to the public.*
[3]*Includes approximately 0.5 miles of road obliteration in Alternatives 2 and 3.*
[4]*No County roads are being closed by this project.*

The Direct and Indirect Effects of Implementing Alternatives 2 and 3

Forest Service and County Road Reconstruction

Approximately 4.7 miles of permanent Forest Service roads would be constructed/reconstructed to access harvest units that currently have inadequate access. Of these, 3.0 miles of roads would remain open to the public (Level 2), with the remainder reserved for official use by the Forest Service (Level 1) (Table 3-48).

The reconstruction of County roads, including two sections of relocation, is necessary because of land and road ownership patterns in the Project Area. Approximately 2.5 miles of County road

would be reconstructed. Two segments of road approximately 0.9 miles in total would be relocated as agreed to by the County onto Forest Service ownership with a right of way granted to the County by the Forest Service (Table 3-48).

These roads are primarily needed to access the timber harvest units. Minor adjustments in road clearing limits or realignment of the existing roads may be necessary to accommodate harvesting equipment. Road reconstruction activities would impose short-term visual impacts because of the cleared vegetation, exposed mineral soils, and the presence of heavy equipment. These visual impacts would decline as the areas become re-vegetated. Sites used as landings would be rehabilitated after the harvest operations are completed to promote re-vegetation by native species and to reduce compaction and erosion potential. Driving surfaces of roads needed for timber sales would be improved or maintained in current conditions during timber sale activities.

The direct effects of Alternatives 2 and 3 would be that the public would have the same access to the Project Area. The existing road system in the Project Area would be improved with existing roads reconstructed to a higher standard. This would be accomplished by removing roads that are unnecessary or in sensitive areas. The road system would still allow users to adequately access the area for recreation and would allow local traffic to pass through the area on an improved road system.

Forest Service Road Closures

It is important to understand that the Forest Service, through the implementation of this Project, would not be closing any County roads. Approximately 3.9 miles of currently open Forest roads would be closed in Alternative 2 and approximately 2.8 miles of currently open Forest roads would be closed in Alternative 3. The effect of the closures in Alternatives 2 and 3 would be minimal due to the large number of County roads throughout the Project Area. In the Project Area, there are 73.5 miles of County roads and 8.7 miles of Forest roads that make up 10% of the total road system. Within the Forest Service ownership of the Project Area, the percentage is higher with 8.2 miles of Forest roads and 15.5 miles of County roads. The Forest Service percentage is 35%. Though the Forest Service is closing up to approximately 50% of its roads with in the Project Area as a whole and on its ownership, the effects on the public should be minor.

The Cumulative Effects of Implementing Alternatives 2 and 3

Forest Service and County Road Reconstruction

In the past, roads have been created by the Forest Service, in and around the Project Area, for the purpose of extracting timber. Many of these roads have been left open for public use. There are also roads that have been created by the public for recreation.

Roads that do not appear on the MVUM and are discovered in the Project Area in the future may be closed and rehabilitated to reduce the erosion potential and vehicle use of these roads. Land pressures on non-forested lands would likely increase as population trends increase. This would likely cause more fragmentation and private roads on properties adjacent to the Project Area.

Forest Service Road Closures

The cumulative effects of closing the Forest roads in both alternatives would be a reduction in roads in sensitive areas, and areas where they are not needed or another road is present, but would have a minimal impact on the Project Area and the surrounding lands.

The combination of the roads that existed on the landscape prior to becoming part of NFS lands, roads that were designed and developed to conduct management activities on the HMNF, user-created roads, and roads that are under the jurisdiction of others (i.e. County and private) have resulted in a Project Area where Forest users are rarely greater than ½ mile from some sort of road. This is consistent with other portions of the HMNF as Table 3-49 illustrates.

Proximity of HMNF Lands to Existing Roads
Table 3-49

Forest Unit	Total Acres	Acres within ¼ Mile of Road	Acres within ½ Mile of Road
Manistee National Forest	538,700	418,300 (78%)	519,500 (96%)
Huron National Forest	439,700	294,700 (67%)	400,300 (91%)
Total	978,400	713,000 (73%)	919,800 (94%)

Forest and County-maintained roads would continue to be utilized to conduct management activities throughout the Project Areas under Alternatives 2 and 3. Improvements would be necessary on some of these roads in order to accommodate these management activities. The level of improvements that are maintained would vary based on the existing and anticipated use of the road at the time of improvement.

Economics

Existing Condition and Resource Specific Information

Unlike other resource areas that are addressed in this assessment, the effects that the Bigelow-Newaygo Project would have on the economy are more difficult to quantify. This is because local economic trends are influenced by a wide variety of factors that extend beyond the local level. While deciding to implement specific activities may have obvious quantifiable economic effects in the short-term (i.e. the amount of timber harvested at the current market rates), how these activities may impact the economy in the long-term (i.e. shifts in preferred recreational use) can only be estimated.

Traditionally, the timber and recreation resources on the HMNF contribute to the economic well-being of the communities in northwest Michigan. For example, timber harvesting and other associated projects on the HMNF affect the local economy by supplying timber to local mills, providing employment to local contractors to harvest the timber, and employing other contractors to complete reforestation, roadwork, and wildlife-related work.

In addition, the presence of public lands in Newaygo County also generates service-related employment and the income that is commonly associated with seasonal resident and tourism

spending. This employment ranges from the support businesses (i.e. gas stations and grocery stores) in the local towns and villages (i.e. White Cloud and Newaygo) to the local homeowner that sells firewood to those coming into these areas to recreate.

Area of Analysis

The area of analysis for the direct and indirect effects on the economy is the Project Area, and the adjacent lands within 50 miles of the Project Area. This represents a typical commuting distance for those who may be employed in the implementation of the proposed activities and a reasonable customer base radius for business owners that may be potentially impacted. The area of analysis for the cumulative effects on the economy is northern Lower Michigan. This large area represents the supply of wood raw materials to manufacturers of forest products, and also corresponds to the location of the range of recreational opportunities favored by Forest users and tourists.

The Direct and Indirect Effects of Implementing Alternative 1

Alternative 1 would not generate revenues for the US Treasury from the sale of timber raw materials. Employment opportunities arising from timber harvesting, wood products, and restorative habitat improvement projects would not occur within the Project Area.

Indirectly, this alternative would contribute to increased costs to the Forest associated with the continued law enforcement and patrol of areas left open to motor-vehicle access within the Project Area. These costs would not vary between the Action Alternatives in other portions of the Project Area, as the existing road system would remain mostly intact.

There would be no direct effects to the existing recreational use within the Project Area under this alternative. The existing transportation system would remain in place (consistent with the MVUM). Horse use would continue to be allowed throughout the Project Area. This continued use would contribute to the local economy through the indirect support of local businesses and, to a lesser extent, local private landowners that provide the goods and services related to the tourism and recreational industries.

The Cumulative Effects of Implementing Alternative 1

Taking No Action within the Project Area would provide no additional employment and income, other than that available under the prevailing general conditions within Northern Lower Michigan. No timber harvesting in the Project Area would most likely shift these effects to other areas where an equivalent amount of employment opportunity occurs. Payments from the 25% Fund that would be generated by implementing the Action Alternative would shift away from Newaygo County. As the existing forested stands would remain classified as such, these areas would be eligible for commercial harvesting entries in the future. Payments to the respective Counties would be deferred until the time when harvesting activities occurred.

The Forest would continue to provide wood products as opportunities arose in the reasonably near future. The harvesting and use of these products would continue to be influenced by supply and demand. Historically, the price of timber increases as the demand increases. During these times, the amount of harvesting that occurs on private land also increases. Conversely, timber prices decrease as demand decreases. During these times, the amount of harvesting that occurs on private

lands also decreases. While the availability of timber on NFS lands would remain consistent, the revenue generated from the sale of timber would continue to fluctuate with the market demand.

Timber harvesting in northern lower Michigan accounted for 40% of the State's industrial roundwood and 52% of its saw log production in 1998 (USDA 2003b). A current search of the MDNR forest products database lists 544 reported businesses that employ personnel connected to the procurement, processing, and manufacture of wood products in the northern lower peninsula of Michigan (MDNR 2010). This is an increase of 10 businesses since 2008, though it is unclear if this increase is due to better reporting or an actual net increase in the total. Within the recent past, two large pulp mills have closed or reduced production, largely for competitive business reasons (Traverse City Record Eagle 2006).

These events have reduced the total employment in the timber harvesting and manufacturing sectors by a significant factor in northern lower Michigan. The competitive, global nature of the paper industry will likely reduce employment in pulp mills in the future; however, employment in sawmills will decline at a smaller rate due steady saw log production levels and fewer capital investments (Leefers 2006). A decrease of over 22,000 or 25% of the forest product industry jobs were lost between 2000 and 2004 with only 99 of these job losses from the logging and forestry category which is less than 5% of this category (Berghorn 2005)

Opportunities for recreation would continue to be provided on private and public lands within the Project Area and throughout northern lower Michigan. While the exact locations and types of recreation that people engage in throughout the region is impossible to predict, this part of Michigan has an economy that is based on providing goods and services in support of recreational tourism throughout the year. This would not change as a result of this project.

Property values throughout northern Michigan fluctuate greatly based on the type of land, the location, and the use. The existing land-use mosaic includes the following trends: 1) urban areas are expanding, with adjacent areas that were formerly larger blocks of contiguous ownership being broken up into smaller parcels; 2) areas with soils capable of sustaining agriculture are still in production; 3) areas without soils capable of sustaining agriculture remain in a forested, open, or developed condition; 4) few large tracts of private land remain in single ownership; and, 5) public lands remain largely fragmented by private ownership; and, 6) private property within the Forest boundary (and adjacent to waterways) includes seasonal homes or non-homestead property.

Fluctuations in property values may occur due to local, State, or national market trends and as a result of the site-specific characteristics of individual properties. Individual consumers have little control over the market trends in real estate. The site-specific values associated with individual properties are in some ways related to personal preference. For example, one person may place more value on a solitary dwelling in a country setting, while another may place more value on an urban dwelling with neighbors close by. Therefore, management activities that affect an existing environment may decrease the value of that environment to one landowner and increase the value of the environment to another. This alternative would continue to provide adjacent landowners with an environment that is consistent with what has been present historically.

The duration and magnitude of Alternative 1 will not incrementally add to past, present and reasonably foreseeable economic forces and events within the MNF, primarily because the Forest contributes less than 2% of the employment and income effect to the local economy.

The Direct and Indirect Effects of Implementing Alternatives 2 and 3

Under Alternatives 2 and 3, commercial timber harvesting activities would return money from the US Treasury to Newaygo County for use in education and road maintenance. Timber sale activities have preparation and administration costs, such as employee wages, road construction, and the regeneration of harvested areas that would remain classified as commercial forestland. The amount of income from timber sales is variable based on the type, quality, and quantity of timber. Typically, timber sales produce revenue which is then utilized to conduct other management activities that are within the Project Area. Additional funds that are generated are then returned to the US Treasury.

The timber that is within this Project Area that would be harvested under these alternatives would not be likely to produce enough funds to cover the combined cost of doing this analysis and preparing the sale areas (layout, road improvements, timber marking, etc.). Additional funding would be necessary to accomplish the program of work required to accomplish the successful restoration and creation of the savanna ecosystem in this area. Due to the adaptive management approach that is used for these activities, the costs associated with these activities are extremely variable. For example, two adjacent areas would likely require different levels of treatments (both in type and scale) to successfully bring the restoration to completion. While prescribed burning alone may be sufficient at one site, an adjacent site may require tree harvesting, tree and stump removal, prescribed burning, and the seeding in of native vegetation. As a result of the differences in these types of treatments, the costs can vary considerably.

The closing of roads within the Project Area would not cause a major shift in the type of recreational use within this area. The majority of existing use in this area is dependent on motorized vehicle access, either directly (i.e. driving for pleasure) or indirectly, i.e. the hauling of campers or horse rigs. In the short-term, this shift would likely have minor economic impacts for those that are immediately adjacent to the Project Area; however, these impacts would not be likely to extend beyond the boundaries of this analysis (50 mile radius).

In other areas throughout the Project Area, the short-term recreation use on the Forest would be displaced during harvesting operations and periodically thereafter during the follow-up restoration treatments. This displacement would not have lasting economic impacts within the analysis boundary, as users would likely move to other adjacent areas on the Forest during the period of displacement.

Table 3-50 measures financial efficiency, and only includes average FY 2014 HMNF's program costs and market-based values (revenues received directly) for Alternatives 2 and 3. The Forest Plan measures economic efficiency using present net value, which compares the discounted benefits and the costs of market and non-market resources. Non-market resource values predominant in the Project Area include hunting, fishing, horseback riding, camping, picnicking, and viewing wildlife; however, a present net value is not calculated because these resources have values assigned at scales larger than the Project Area. In general, non-market values between Alternatives 2 and 3 are equivalent, where a change in scenic attractiveness is offset by restoring recreation sites and early habitat production, which particularly increases game wildlife viewing opportunities.

Table 3-50 displays costs and revenues for Alternatives 2 and 3 for the timber harvesting activities and the required payments of the Project. The values included in this table are estimates based on those areas where timber resources may be of commercial quality and quantity.

Estimated Revenues and Costs for Harvest Activities
Table 3-50

Activity/Unit Cost	Alternative 2	Alternative 3
Acres harvested	1,833	1,606
CCF harvested	25,801	22,663
Sale of stumpage - Gross revenue	$1,167,980	$1,050,560
Estimated road improvement costs	$177,000	$177,000
Reforestation surveys	$1,000	$1,000
Total Costs	$178,000	$178,000
25% Fund Payment to Counties	$291,995	$262,640
Grand Total	$469,995	$440,640
Net Revenue	$697,985	$609,920

In addition to the costs and revenues associated with timber harvesting activities, this project would have costs associated with the creation/restoration of areas to savanna. These activities would be adaptive in nature, meaning that follow-up treatments would be based on the results of previous treatments, based on monitoring. As a result, determining an exact cost for the creation/restoration of savanna is not possible. The values that are shown in Table 3-51 are estimated values based on the initial treatment and do not take into consideration whether the work is carried out by Forest Service personnel or is accomplished through the use of a private contractor. As a result, the values would likely vary greatly from what is shown. Factors that may affect the cost of implementing these activities are described below:

Broadcast Burning

The cost-effectiveness of this activity increases with the amount of area that can be incorporated per burn (i.e. larger burns are more cost-effective than smaller burns on a per unit basis). Larger burns can reduce the cost per acre by utilizing already established containment lines (i.e. roads), reducing mobilization (i.e. equipment and personnel), and the number of required individual burn plans. Under Alternatives 2 and 3, all of the units proposed for savanna creation/restoration would include the use of prescribed burning as a tool for establishment and maintenance. Other areas have also been included to meet other management objectives and to reduce the cost/unit of implementing the prescribed burning activities. While it would be expected that many of the areas proposed for savanna creation/restoration would require multiple burns to meet the desired future condition, the costs that are shown for burn activities are reflective of only one burn per unit. This is the minimum that would be required.

Herbicide Non-Woody Vegetation/NNIP

Under Alternatives 2 and 3, these treatments would occur on 10% of the areas proposed for savanna creation/restoration and in the control of the NNIP that has already been identified through botanical surveys. It would be likely that the areas where NNIP control would be necessary would increase in the savanna creation/restoration areas due to an increase in sunlight, disturbance to the upper soil profiles, and NNIP seeds being present (but currently dormant) in the seed bank. As a result, the cost to contain/control these species would likely increase beyond the level of the initial treatments that are reflected in Table 3-51.

Resource Damage Repair

This would address damage from unauthorized recreational ORV use in a number of locations under Alternatives 2 and 3. The work would include fencing, seeding, trail and hillclimb restoration, and signage of the areas.

Savanna Restoration/Creation Site Preparation

The type and amount of site preparation that would be necessary in any given stand would be dependent on the existing condition of that stand. The types of activities would include, but not be limited to stump removal, leveling/grading, chipping, masticating, and disking. The purpose of these activities would be to prepare the soil for the establishment of the native seed patches that would not exceed 10% of the treatment areas. The value that is shown for this assumes that no more than 10% of the areas being converted/restored to savanna would require site preparation and that site preparation would only need to occur once.

Seeding of Native Plants

Under Alternatives 2 and 3, the seeding of native plants would occur in the same locations as, but following, site-preparation. This area would not be expected to exceed 10% of the total area proposed for savanna restoration/creation. The amount and type of native seed that would be used in these areas is variable and largely dependent on what emerges from the existing soil seedbank. The cost of native seed is also variable. The value of seed displayed in Table 3-51 is intended to be used as an average, with a seeding rate of 10 lbs/acre.

Road Stream Crossings

Under Alternatives 2 and 3, there are two basic objectives for road improvements; 1) providing for aquatic organism passage and 2) reducing sediment routing from the road surface to the respective channel. The total cost for each road-stream crossing improvement would vary according to a variety of other characteristics specific to each site (i.e. quantity of road fill, structure type, etc.). A good average cost would be $150,000 for each crossing, for a total cost of $1,450,000.

Riparian Plantings

Under Alternatives 2 and 3, the 17 acres of riparian plantings along Bigelow Creek would use a variety of tree types, including but not limited to white pine, hemlock, silver maple, and potentially white cedar. Some species may require protection from wildlife browsing, in which case additional cost installing protection measures, preferably fence exclosures.

Instream Structure Maintenance

Under Alternatives 2 and 3, each structure would be augmented with small trees and/or branches secured to the adjacent stream bank at an average cost of $400. Total cost is estimated at $11,200.

Mechanical/Cutting Removal of Woody Vegetation

Vegetation would be treated mechanically in timber harvest and non-harvest units with a variety of equipment. This could include, but is not limited to hotsaw, processor, bushhog, bulldozer, masticator, and other machinery. This would facilitate removal of woody stems too small for commercial harvest. The material could be removed off site, piled, pile and burned or any combination of these. Approximate prices for this activity are in the $200 to $300 range.

Manual Cutting/Removal of Woody Vegetation

Treatments would include all types of manual vegetation removal. This would be used primarily where material to be cut is small sized and low density per acre and in locations that would be sensitive to large equipment. The material could be removed from site, piled or piled and burned or any combination of these activities. Due to the intensive amount of labor, required costs are much higher than for mechanical vegetation treatments.

Habitat Protection Measures

This could include barrier posts, rocks, earthen berms, and signs installed by the Forest Service or contractors. The costs associated with this could vary widely because of area size, topography, proximity to roads, and the effects of vandalism.

Prescribed Burning

See *Broadcast Burning* above. This would apply to the savanna, opening creation, and maintenance treatment areas as funds and conditions allow.

Herbicide Woody Vegetation

This activity would apply to the areas under Alternatives 2 and 3 where savanna creation and opening restoration would occur. The implementation would consist of spot-treatment of sprouting stumps, with the amount required dependent on the number and type of stumps per acre. For example, it would be expected that the amount of stumps treated in the pine stands and open areas would be less than that of existing forested oak stands. How much would depend on the existing location and cover type characteristics. The value that is reflected in Table 3.45 assumes that all of the stands would require approximately the same level of treatment and that the treatments would be necessary on every acre that is proposed for treatment.

Road Closing

The costs associated with closing roads would vary by the type of closure. For example, at one location a gate may be sufficient, while at another location the gate may need to be reinforced with barrier posts. For this project, all of the roads that would be closed would also be needed for future administrative purposes (i.e. conducting KBB management activities or special-use access).

As a result, locked gates, in conjunction with barrier posts, would be the initial preferred method of closure.

Non-timber Related Costs for the Bigelow-Newaygo Project
Table 3-51

Activity[1]	Estimated Measure		Estimated Amount per Acre	Total By Alternative	
	Alternative 2 Acres	Alternative 3 Acres		Alternative 2	Alternative 3
Broadcast burning (ac)	700	750	$150	$105,000	$112,500
NNIP herbicide treatment (ac)	108	108	$300	$32,400	$32,400
Resource damage repair (each)	270 on 19 sites	251 on 19 sites	$300	$81,000	$73,500
Savanna site preparation[2] (ac)	100	100	$100	$10,000	$10,000
Site prep/seeding of native plants[2] (ac)	242	152	$2,500	$605,000	$380,000
Road stream crossings (each)	9	9	$150,000	$1,350000	$1,350,000
Riparian planting (ac)	17	17	$150	$2,550	$2,550
Instream structure maintenance (each)	28	28	$400	$11,200	$11,200
Mechanical removal of woody vegetation[2,3] (ac)	932	700	$250	$233,000	$125,000
Manual removal of woody vegetation[2,3] (ac)	932	700	$1500	$1,389,000	$1,050,000
Habitat protection measures[2,3] (ac)	932	700	$200	$186,400	$140,000
Prescribed burning[2,3] (ac)	932	700	$150	$139,800	$105,000
Herbicide woody vegetation[2] (ac)	100	100	$300	$30,000	$30,000
Road closing (miles)	4	2.9	$1,000	$4,000	$2,900
Total Costs				**$4,715,550**	**$3,816,650**

[1]*Calculations for these activities are based on the maximum potential area treated. Actual costs for these activities would vary by the effectiveness of treatments and the results of monitoring.*
[2]*These activities would be conducted, as funding is available up to the acres shown.*
[3]*These activities or a combination of them would occur on the same 932 or 700 acres, respectively by alternative.*

The Cumulative Effects of Implementing Alternatives 2 and 3

Under Alternatives 2 and 3, there would be additional employment opportunities associated with timber harvesting activities and the creation and restoration of the savanna ecosystem. Employment opportunities would likely be in the form of contractors and seasonal and permanent staff. Included would be such activities as timber sale layout and administration, timber harvesting, timber stand site preparation, regeneration surveys, savanna site preparation, NNIP/savanna herbicide application, seeding and planting, road and parking lot construction and maintenance, and wildlife surveys. Further contributions to the economy would occur through the purchasing of materials and supplies necessary to accomplish the work. These activities would occur over a period of up to 10 years and, when compared with the economy of northern lower Michigan, would have little to no impact on the prevailing conditions.

In addition to the projects that would be implemented under Alternatives 2 and 3, other similar types of projects would also be likely to occur within this Project Area and in other locations of the HMNF. These projects would also contribute to the economy of northern lower Michigan and would likely have beneficial cumulative effects on the public and private natural resource management sector.

In addition, the implementation of either of these alternatives may provide payments from the 25% Fund which would be used to assist in the funding of improved transportation systems and education within the counties where treatment activities are proposed. These same types of funds would be available to other counties where similar types of projects occur. While individual projects would likely have only a small impact on the respective county coffers, cumulatively the income generated from the 25% Fund could serve as an important supplement in counties that have been hit the hardest by the recent economic downturn.

Under Alternatives 2 and 3, the acres receiving savanna creation/restoration treatment would be removed from the suitable commercial forestland base of the Forests. While the respective counties would receive payments as a result of the receipts from this project, similar payments from the savanna creation/restoration areas would not occur in the future. This loss of income would likely be offset by payments from the 25% Fund as a result of other harvesting activities occurring in areas of the Forest that remain part of the commercial base. Currently, the Forest has approximately 400,000 acres of land suitable for timber management to meet the ASQ for the first decade. This equates to 15.2 million cubic feet per year (USDA 2012c). Forested timberlands are those which produce a minimum of 20 cubic feet of fiber/acre/year and that are currently not withdrawn from timber production. Approximately 380,000 acres of forested timberlands are required to meet the current ASQ. The remaining Forestlands are not targeted for timber production, but are anticipated to contribute some timber volume that does not contribute to the ASQ in the next 20 years. In conjunction with Project Area non-timber resources, Alternatives 2 and 3 contribute to the positive increase of *Non-market Present Net Values* in the Table III-54 in the Forest Plan.

Under Alternatives 2 and 3, opportunities for recreation would continue to be provided on both private and public lands within the Project Area and throughout northern lower Michigan. While the exact locations, types, and future trends of recreational use throughout the region is impossible to predict, this part of Michigan has an economy that is based on providing goods and services in support of recreational tourism throughout the year. This would not change as a result of this project.

As a result of the activities associated with the creation and restoration of savanna, Alternatives 2 and 3 would alter the viewshed of adjacent private landowners within portions of the Project Area. While these changes may impact the perceived property values to the existing private landowners, there may be others who would prefer the viewshed that would be created. The projects proposed under these alternatives are not expected to cause fluctuations in the values of real estate within or adjacent to the Project Area, especially when compared with occurring trends across the northern lower peninsula of Michigan.

Other cumulative economic effects would be similar to those discussed under the No Action Alternative.

The duration and magnitude of Alternatives 2 and 3 would not incrementally add to past, present and reasonably foreseeable economic forces and events within the MNF, primarily because the Forest contributes less than 2% of the employment and income effect to the local economy.

Management Indicator Species and Wildlife

Area of Analysis

The area of analysis for the direct and indirect effects on wildlife resources is the NFS lands where treatments will occur, and adjacent public and private lands included within the Bigelow-Newaygo Project Area boundary. The cumulative effects analysis area for wildlife resources encompasses the Manistee portion of the HMNF. The size of this area provides an adequate geographical range to consider the effects that this project may have on the viability of the individual species that are considered in this analysis over the anticipated length of the project (approximately 10 years).

Existing Condition

The HMNF provide habitat for 382 species of breeding vertebrate animals. These include 168 birds, 54 mammals, 24 reptiles, 18 amphibians, and 118 fishes. The HMNF also provides habitat for a large number of invertebrates, primarily insects, and numerous migratory species in addition to those species breeding on the HMNF. Although a comprehensive survey of the Project Area does not exist, many of these species are assumed to occur in the Project Area. Of these, a total of 47 animal species are tracked as RFSS, including 5 mammals, 17 birds, 6 reptiles, 3 bivalves, 10 insects, and 6 fishes (USDA 2012b). In addition, the 2012 Forest Plan identified four wildlife species to serve as MIS: bald eagle, ruffed grouse, Kirtland's warbler, and KBB (USDA 2012c). These species were selected because they represent particular environmental conditions for a variety of species needing similar habitat conditions. Of these, only the bald eagle, ruffed grouse, and KBB occur in the Project Area.

The HMNF considered the effects of forest management on these species through the development of the Forest Plan. A list of MIS, RFSS, and federally Threatened and Endangered species and management direction for these species on the HMNF are found in the Forest Plan and Final Environmental Impact Statement (USDA 2012c; USDA 2012d). In addition, most of the species tracked as RFSS have species viability evaluations, conservation assessments, or risk evaluations (USDA 2005b; USDA 2006a). Additionally, recovery or management plans have been prepared for all Threatened and Endangered species and critical habitats on the HMNF; there is no federally designated critical habitat for any species in the Project Area. Since the Forest Plan was signed and amended, the northern long-eared bat has been proposed to be listed as Threatened under the

Endangered Species Act (ESA). The HMNF is currently conferencing with the USFWS on the potential effects of forest management activities on this species.

Trends for wildlife MIS on the HMNF are discussed in the 2010-2011 Monitoring and Evaluation Report (USDA 2013c). A viable and healthy population of ruffed grouse exists on the HMNF. Generally, ruffed grouse populations seem to have a 10-year population cycle in Michigan. The monitoring information for ruffed grouse indicates the HMNF population may be trending downward from a peak in 2009 toward the low phase of the 10-year cycle. The number of productive bald eagle territories established in and near the HMNF, as well as the number of fledglings per nest, has increased over the last two decades. Although KBB populations are decreasing on the HMNF, the HMNF has been actively increasing hundreds of acres of savanna habitat through restoration activities since 2006, and several of these savanna conversion areas have recently become occupied by the species.

According to the 2010-2011 Monitoring and Evaluation Report, the status of most of the vegetation types currently represented on the HMNF is generally consistent with projections in the Forest Plan. However, the HMNF is not meeting Forest Plan projections for aspen/early successional habitat, prairies, savannas, or barrens. Few acres of early successional habitat are being managed annually on the HMNF, while the amount of late successional wildlife habitat is increasing proportionally as the forest grows older. These trends influence the diversity and abundance of wildlife on the HMNF and in the Project Area.

Breeding Bird Survey (BBS) population trends for the State of Michigan from 1999-2009 have shown most species that prefer mature forests on the HMNF are stable or increasing (Sauer et al 2011). Whereas, species that prefer early successional or scrub habitats show mixed trends. The BBS trends also indicate a significant proportion of grassland bird species are declining. Although not a MIS, a migratory bird of interest and RFSS on the HMNF is the northern goshawk. Although breeding activity remains at a low level, most of the northern goshawk pairs that attempt breeding on the HMNF successfully raise young; thus, the population on the HMNF is considered stable.

Wildlife Species Habitat Associations

Early-Successional Vegetative Types

Early successional wildlife species are declining in Michigan due to habitat loss and degradation, as well as direct mortality from land management activities and human interactions, such as vehicle collisions and trampling (USDA 2005b). Openings, prairies, grasslands, savannas, and barrens have declined within the HMNF over the past century due to extensive reforestation, fire suppression, and the processes of natural succession. As remnant openlands fill in with fire intolerant woody and shade tolerant herbaceous species, suitable habitat for species such as the KBB, a federally-listed endangered species, and MIS associated with oak/pine savanna and pine barren communities is becoming scarcer. The decline in KBB habitat quality and quantity within the HMNF has led to a reduction in occupied subpopulations. Remnant populations of KBB and other early successional animal and plant species currently occur within small patches of prairies, grasslands, savannas, and barrens that are widely scattered and disconnected across the Project Area and HMNF. Early successional forest types (such as aspen) also are gradually being lost due to succession. Forest maturation on the HMNF and in the Project Area may be reducing habitat quantity and quality for ruffed grouse, a MIS associated with early successional forests dominated

by aspens and poplars. Other game and non-game wildlife species that may be associated with early successional forests, openings, prairies, grasslands, savannas, or barrens within the Project Area include, but are not limited to: hill-prairie spittlebug, dusted skipper, golden-winged warbler, frosted elfin, Persius duskywing, red-headed woodpecker, prairie warbler, whip-poor-will, eastern box turtle, American woodcock, cottontail rabbit, snowshoe hare, fox and gray squirrel, red and gray fox, coyote, wild turkey, and white-tailed deer.

The Forest Plan emphasizes management for oak barrens/savanna ecosystems, particularly for KBB conservation, and directs the restoration and maintenance of 20,300 acres of savanna/barrens within designated KBB population management areas and essential KBB habitat within the HMNF over the life of the Forest Plan. The Forest Plan also calls for the restoration and maintenance of 30,000 acres of upland openings across the HMNF. Currently, 739 acres of upland openings and 120 acres of prairies occur within the Project Area, including three remnant areas of dry sand prairie in the Newaygo Prairies RNA and one remnant area of dry sand prairie in the Newaygo ESA. In addition, the Forest Plan recognizes the importance of early successional forest communities, identifying a goal of approximately 2,400 acres of aspen regeneration harvests and approximately 200 acres of jack pine regeneration harvests annually to create early successional habitat for a variety of species. Currently, none of the approximately 263 acres of quaking-bigtooth aspen, 76 acres of oak-aspen, 88 acres of jack/Scots pine, or 142 acres of red/jack pine-oak stands within the Project Area are in an early successional stage (<10 years of age). Only 5 acres of oak-eastern white pine exist in the 0-9 year age class within the Project Area. However, in the 10-19 year age class, there are 37 acres of red/white pine, 8 acres of black/white oak, and 50 acres of quaking-bigtooth aspen.

Mid- to Late-Successional Forest Types

Currently, 86% of the Project Area consists of mid- to late-successional forest types. Mid-successional forest types (40-79 years of age) include 66 acres of jack pine/Scots pine, 2,157 acres of red/white pine, 118 acres of oak-eastern white pine, 39 acres of oak-aspen, 138 acres of red/jack pine-oak, acres of black/white oak, 326 acres of black/white oak, 408 acres of mixed oaks-red maple, and 155 acres of quaking-bigtooth aspen. Late-successional forest types (>80 years of age) include 217 acres of red/white pine, 113 acres of oak-eastern white pine, 37 acres of oak-aspen, 1,055 acres of black/white oak, 1,328 acres of mixed oaks-red maple, 161 acres of mixed northern hardwoods, 210 acres of mixed lowland hardwoods/conifers, and 58 acres of quaking-bigtooth aspen. Game and non-game wildlife species that may be associated with mid- to late-successional forest types within the Project Area include, but are not limited to: northern long-eared bat, northern goshawk, red-shouldered hawk, bald eagle, Louisiana waterthrush, eastern box turtle, pileated woodpecker, brilliant scarlet tanager, black bear, red and gray fox, coyote, black-throated green warbler, gray and fox squirrel, white-tailed deer, and bobcat.

Acreage of mid- to late-successional forest types has increased within the HMNF over the past century. However, forest fragmentation and disturbance/destruction of nesting, roosting, denning, and foraging sites resulting from timber harvest, road construction, and recreation threatens the viability of species associated with these forests (USDA 2005b; USDA 2006a). Management for early successional vegetative types as directed under the Forest Plan would involve the conversion of mature forest stands which could adversely affect these species, although conservation measures can minimize these threats.

Streams, Creeks, Lakes, and Wetlands

There are several rivers, streams, creeks, lakes, and wetlands within the Project Area (see Aquatics section). These water bodies and their associated uplands may provide habitat for waterfowl and shorebirds, such as great blue heron, common loon, wood duck, mallard, black duck, Canada goose, and other water-oriented species such as beaver, spotted turtle, Blanding's turtle, and wood turtle. Bald eagles may also forage for fish and waterfowl within these water bodies. In Michigan, the viability of these species is being threatened by habitat loss and degradation, disturbance of foraging and nesting animals, and increased mortality resulting from human activities such as draining wetlands for agriculture, development adjacent to water bodies, road construction, recreational activities, pollution, and illegal collection (USDA 2005b). The water body most likely to be impacted in the Project Area is Bigelow Creek, which is considered a high quality stream that currently is lacking important characteristics of a healthy aquatic system, such as in-stream woody debris and quantity and quality of shade trees in the riparian area that provides for both fish and wildlife (see *Aquatic Resources* section).

Occurrence of Sensitive Wildlife Species

Proposed or federally-listed Threatened and Endangered (Federal T&E) species, Terrestrial MIS, RFSS, and State-listed Threatened and Endangered species (State T&E) that may be present or have habitat within the Project Area include: KBB, northern long-eared bat, dusted skipper, Persius duskywing, frosted elfin, Ottoe skipper, hill-prairie spittlebug, prairie warbler, red-headed woodpecker, ruffed grouse, bald eagle, common loon, northern goshawk, red-shouldered hawk, eastern box turtle, wood turtle, spotted turtle, and Blanding's turtle. Ottoe skipper and whip-poor-will were recently removed from the RFSS list. However, the Ottoe skipper remains on the State T&E list as Threatened. Whip-poor-will has no special status in Michigan; however, it is one of many bird species protected under the Migratory Bird Treaty Act of 1918. The habitat, ecology and distribution (within Michigan, and, if available, within the MNF) of these species are briefly summarized in Table B3 in Appendix B. Citations are noted where more detailed information can be found concerning individual species ecology, life history, and status.

A BA/BE (see Planning Record) determined the potential effects of the proposed actions on all of the wildlife species listed in Appendix B. Ruffed grouse was not considered in the BA/BE because it is a MIS, not a Threatened or Endangered Species or RFSS. The KBB and proposed northern long-eared bat are known or could occur in the Project Area and therefore were analyzed in the BA/BE to determine the potential effects from implementation of the proposed actions on these federally listed or proposed species. No designated critical habitat exists for any federally-listed Threatened and Endangered species in the Project Area; therefore, none were analyzed in the BA/BE.

The Project Area is within the potential breeding range for the northern long-eared bat. Roost trees that could provide suitable habitat for maternity colonies (i.e. live and dead trees and/or snags ≥3 inches diameter at breast height (DBH) with hanging bark, cavities, or crevices) occur throughout the Project Area. Although northern long-eared bats may occur within the Project Area during the breeding season, individuals are unlikely to be present during the winter as large caves and mines suitable to serve as hibernacula are not present.

There are 48 openings and savannas covering approximately 884 acres that have documented occurrences of KBB within the Project Area. Most (88%) of the documented occurrences are

located on non-NFS lands. Over the last two decades, non-profit organizations, local and State government agencies, and private landowners have been actively managing over 750 acres to restore oak-pine savannas for KBB and other plants and animals dependent on this rare ecosystem. In 2009, the HMNF worked with The Nature Conservancy, Land Conservancy of West Michigan, MDNR, and Newaygo County Michigan State University Extension to develop the Newaygo Prairies Conservation Action Plan (Legge and Pearsall 2009). One of the objectives of this Plan was to cultivate opportunities to conduct cooperative management activities, particularly prescribed burns, across different landownerships to restore oak-pine savannas for KBB and other lupine dependent butterflies (Legge and Pearsall 2009). Given only 12% of documented occurrences of KBB occur on NFS lands within the Project Area, the planning team recognized conducting cooperative management activities with adjacent landowners was essential to achieve the recovery goals outlined in Final Recovery Plan for the KBB (USDI 2003). As such, during the development of the Newaygo Prairies Conservation Action Plan, NFS lands adjacent to areas being managed for KBB on other ownerships were identified for inclusion in a future NEPA document, such as this one. Stands proposed for savanna creation, opening restoration, and opening creation treatments under the Proposed Action include the NFS lands identified by the planning team as priority areas for restoration to promote the expansion of existing KBB subpopulations. Documented occurrences of KBB within, adjacent to, or within dispersal distance of Forest Service stands proposed for treatment within the Project Area are presented in Table B2 in Appendix B.

MIS, RFSS, and State T&E associated with early-successional vegetative types that have documented occurrences within the Project Area include dusted skipper, Persius duskywing, frosted elfin, Ottoe skipper, hill-prairie spittlebug, prairie warbler, red-headed woodpecker, ruffed grouse, whip-poor-will, and eastern box turtle (see Table B3 in Appendix B). Occurrences of these species are documented within numerous openings, prairies, savannas, grasslands, and barrens scattered throughout the Project Area. Over the past century, the number and size of openland habitats within the Project Area has decreased due to the process of natural succession, fire suppression, and extensive reforestation, particularly conversion of openlands to red pine plantations. As a result, remnant openings, prairies, savannas, and barrens are common within forested stands within the Project Area. MIS, RFSS, and State T&E associated with early-successional vegetative types have been documented within these remnant openlands, as well as within road, power line, natural gas pipeline, and railroad right-of-ways that provide corridors between extant openlands within the Project Area.

RFSS associated with mid- to late-successional forest types that have documented occurrences within the Project Area include bald eagle, Louisiana waterthrush, northern goshawk, red-shouldered hawk, and eastern box turtle (see Table B3 in Appendix B). No proposed treatment units are within close proximity (within ½ mile) to any known bald eagle nests or roosts, and the Project Area is located outside essential bald eagle habitat on the HMNF (USDA 2006b). The closest known active bald eagle nests are documented within the oak/pine forests around Croton Dam Pond and along Penoyer Creek, which are over 0.32 miles from proposed treatment units. However, potential foraging habitat for bald eagles may occur within the Project Area. In addition to having documented occurrences within numerous openings, prairies, savannas, and barrens scattered throughout the Project Area, eastern box turtles have been observed in forested stands proposed for treatment and near Toft Lake. During surveys conducted in 2013, Louisiana waterthrush were observed within stands proposed for treatment along Penoyer Creek. Occurrences of active northern goshawk and red-shouldered hawk nests also have been documented in several forested stands proposed for treatment within the boundaries of the Project

Area. Northern goshawks have been reported nesting in Compartments 576 and 578, and red-shouldered hawks have been reported nesting near Croton Dam Pond and Tamarack Creek. However, no activity was reported within known northern goshawk and red-shouldered hawk nesting territories during surveys conducted in 2011 and 2013.

Blanding's turtle, spotted turtle, wood turtle, and common loon are RFSS that could be associated with lakes, rivers, and creeks within the Project Area (see Table B3 in Appendix B). Blanding's turtle, wood turtle, and spotted turtle are documented to occur in and near several rivers and creeks that are within dispersal distance (0.5 miles) of proposed treatment units. Blanding's turtle is documented to occur in forested stands and wetlands near Tamarack Creek, and was observed crossing Beech Road near Little Muskegon River during surveys in 2013. Occurrences of wood turtle have been documented in Bigelow Creek, Pettit Lake, Muskegon River, and Brooks Creek and in several neighboring upland openings. Spotted turtle is documented to occur in forested stands and openings near Tamarack Creek and Little Muskegon River and was observed crossing Gates Road during surveys in 2013. The closest known active common loon nests are documented on Pettit Lake and Brooks Lake, which are at least 0.3 miles from proposed treatment units.

Federally-Listed Endangered and Threatened Wildlife Species

Karner Blue Butterfly - Status and Distribution

In 1992, the KBB was federally-listed as an endangered species in the United States (USDI 2003). KBB occur in heterogeneous oak/pine savanna/barrens habitats with abundant wild lupine (the sole food source for the KBB caterpillar), abundant adult nectar sources, warm season grasses for basking and roosting, and ants to protect larvae from parasites and predators. In addition, to maintain persistent metapopulations, dispersal between subpopulations needs to be maintained by connecting subpopulations with corridors and maintaining an average nearest neighbor distance of ≤1 kilometer between subpopulations. Dispersal usually refers to the movement of individuals within and between suitable habitat sites. Research has shown dispersal of KBB to range from about 600 feet (183 meters) to about 2 miles (3.2 kilometers); however, dispersal distances are generally short, with most movements less than 1/8 mile (200 meters) (Rabe 2001; USDI 2003). Detailed information on the ecology of the KBB and its status on the HMNF may be found in the KBB Recovery Plan, the Draft Management Strategy (USDA 2004a), the Biological Assessment for the HMNF Land and Resource Management Plan (USDA 2006a), the Biological Opinion for the HMNF Land and Resource Management Plan (USDI 2006), and, the Final Karner Blue Butterfly 5-Year Review: Summary and Evaluation (USDI 2012).

KBB habitat has declined within the HMNF over the past century due to extensive reforestation, fire suppression, and the process of natural succession. As naturally occurring open areas filled in with fire-intolerant woody and shade-tolerant herbaceous species, suitable KBB habitat became scarcer. Wild lupine, other important nectar plants, and warm season grasses were shaded out or out-competed. Overstory tree canopies closed, creating more uniform light conditions. KBB corridors disappeared and subpopulations decreased in size and became more isolated. The decline in KBB habitat quality and quantity has led to a reduction in occupied subpopulations within the HMNF.

The Project Area includes the Bigelow Metapopulation Area (BMA) and other adjacent subpopulations scattered within the Newaygo Recovery Unit, described in the KBB Recovery Plan and the Draft Management Strategy. Currently, there are 25 openings and savannas, covering

approximately 454 acres, within the BMA that have documented occurrences of KBB. In addition, occurrences of KBB are documented in 23 openings and savannas, covering approximately 430 acres, adjacent to the BMA. However, most (88%; approximately 778 acres) of the documented occurrences are located on non-NFS lands, with only 5% (approximately 106 acres) occurring on NFS lands within the BMA. Because only a small percentage of KBB sites are located on NFS lands and landownership is fragmented throughout the Project Area, only a small subset of known KBB subpopulations has been monitored by the HMNF. Monitoring of most KBB subpopulations within the Project Area has been made possible through cooperative survey efforts with the MDNR, The Nature Conservancy, Consumer's Energy, MNFI, and volunteers from over 34 organizations.

The BWC District and its partners annually conduct surveys to estimate KBB abundance and assess habitat conditions within a selected subset of KBB sites within and adjacent to the BMA. Between 2008 and 2013, the HMNF, in cooperation with partners and volunteers, monitored four KBB subpopulations within the BMA and eight KBB subpopulations adjacent to the BMA, covering approximately 83 and 65 acres on NFS lands and other ownerships, respectively (USDA 2008a; USDA 2009b; USDA 2010; USDA 2011a; USDA 2012e; USDA 2013d). Based on the data collected, the BMA does not meet the goals listed in the KBB Recovery Plan and the Draft Management Strategy. The estimated minimum KBB abundance within subpopulations located in and adjacent to the BMA is below the viable metapopulation goal of ≥6,000 individuals outlined in the KBB Recovery Plan. In addition, marginal habitat conditions are provided within subpopulations in and adjacent to the BMA. None of the subpopulations monitored have both wild lupine cover and cover of other KBB nectar plants between 5-15%, and there are fewer than 5 subpopulations with an average wild lupine stem density >500 stems/acre. The average percent cover of NNIP also is greater than 5% within the subpopulations. Most of the subpopulations are being filled-in by woody vegetation and have an average percent cover of woody plants <2 meters in height >25% and average canopy cover >50%. Furthermore, the subpopulations in and adjacent to the BMA do not meet the distribution and connectivity goals listed in the Recovery Plans. Not only are the subpopulations relatively small, with an average area of 17 acres, but they also are not distributed over 2/3 of a ≥10 square mile area with at least 640 acres of suitable habitat. In addition, the subpopulations in and adjacent to the BMA are mostly isolated and lack sufficient connectivity to promote dispersal. Overall, the subpopulations in and adjacent to the BMA are unlikely to support a persistent metapopulation because they have low numbers of KBB, marginal habitat conditions, are relatively small in size, are not well distributed, are isolated, and lack connectivity. As a result, the metapopulations are subject to a high risk of extirpation from catastrophic events such as wildfire.

Four other KBB metapopulation areas are located within the District's boundaries, two within the Newaygo Recovery Unit (Brohman and Hayes) and two within the Muskegon Recovery Unit (White River and Otto), as described in the KBB Recovery Plan. Currently, none of these metapopulation areas meet the recovery goals for establishing minimum or large viable metapopulations and all are subject to a high risk of extirpation (USDA 2008a; USDA 2009b; USDA 2010; USDA 2011a; USDA 2012e; USDA 2013d). The numbers of acres and sites occupied by KBB, and the number of KBB observed during surveys, have declined within all four of these metapopulation areas. KBB have not been observed within subpopulations monitored in the Brohman Metapopulation Area since 2005. In addition, no new subpopulations were identified within the Brohman Metapopulation Area during inventory or presence/absence surveys conducted in 2007, 2008, 2009, and 2013. Thus, this federally endangered species may be extirpated from the Brohman Metapopulation Area.

The following factors may be responsible for apparent KBB declines in the five metapopulation areas on the HMNF (USDA 2006a; USDA 2013d):

- Habitat loss due to natural succession is continuing despite past treatments that have attempted to prevent woody encroachment into suitable KBB habitat. The number of acres of suitable KBB habitat experiencing woody encroachment is greater than the number of acres of suitable KBB habitat treated annually.
- Deer browsing of wild lupine, which may reduce KBB larval survival, may be increasing within suitable KBB habitat.
- Weather conditions have shifted between drought conditions, very wet and cold springs and summers, and unseasonably warm summers followed by several spring frosts. Variations in temperature and precipitation and the occurrence of spring frosts can reduce over-winter survival of eggs, reduce the availability of nectar plants, and lead to changes in nectar plant phenology, subsequently leading to a decrease in KBB populations.
- Topography of these metapopulation units has low depressional areas, which increases the occurrence of growing-season frost pockets that may damage wild lupine and other nectar plants.
- Vehicle/ORV use, dispersed camping, and horseback riding occurs within suitable KBB habitat, which may inadvertently kill KBB and/or damage wild lupine and other important nectar plants. Road closures and the development of designated non-motorized trails implemented under the Forest Plan's management direction for the White River Special Area, and camp site closures in occupied KBB habitat that have been implemented under Forest Plan Standards and Guidelines have reduced these impacts in some metapopulation areas (USDA 2012c).

Efforts to prevent the extirpation of the KBB have increased dramatically since the Forest Plan was signed in 2006. To meet recovery goals for viable KBB populations, the Forest Plan calls for the restoration and maintenance of 20,300 acres of savannas/barrens designated KBB metapopulation areas and essential KBB habitat on NFS lands over the next 50 years. A minimum of 400 acres per year needs to be restored to meet this goal. Prior to 2006, management strategies implemented by the HMNF failed to restore 400 acres of savanna each year. However, the HMNF has been able to dramatically increase savanna restoration efforts in the last 8 years by leveraging personnel and integrating program goals, developing stewardship projects, obtaining external support such as grants, partnerships, and volunteers, and using an adaptive management approach. Since 1992, hand cutting, prescribed burns, timber harvests, mechanical removal of vegetation (i.e. mowing, shear cutting, masticating, bulldozing), scarification, seeding/planting, weeding and herbicide treatments, and road, trail, and camping closures have been used to manage 2,205 acres of occupied and 2,591 acres of unoccupied KBB habitat (USDA 2013d). These treatments reduce tree and shrub density, protect savanna remnants, and promote growth of native grasses and wildflowers, including wild lupine - the sole food for the KBB caterpillar. However, most (85%) of the acres managed received savanna restoration treatments after 2005 (USDA 2013d). Up until 2005, treatments primarily focused on maintenance of occupied sites. In 2006, treatments shifted to focusing on savanna restoration in unoccupied areas around and between KBB subpopulations.

Partnerships have been essential to promoting savanna restoration across landscapes and jurisdictional boundaries. Because only a small percentage of KBB occurrences are located on NFS lands and landownership is highly fragmented in and adjacent to the BMA, working with partners to conduct cooperative monitoring and management activities is critical to successful savanna restoration efforts. Under Alternatives 2 and 3, the HMNF would continue to work with The Nature Conservancy, Land Conservancy of West Michigan, MDNR, Newaygo County

Michigan State University Extension, and other partners to cultivate opportunities to conduct cooperative management activities, particularly prescribed burns, with adjacent landowners to promote the expansion of existing KBB subpopulations and achieve the recovery goals outlined in the KBB Recovery Plan.

The HMNF also has dramatically increased its KBB monitoring program with the help of volunteers and partners. These efforts include: determining how far designated metapopulation areas within the HMNF are from meeting recovery goals; developing and validating a habitat suitability model for KBB within the HMNF; predicting KBB occurrence and restoration success within proposed treatment areas; identifying high priority areas to target management; evaluating the effectiveness of different management strategies for restoring savannas and KBB habitat; and developing a management strategy that is responsive to climate change. With the help of volunteers, the HMNF was able to increase effectiveness monitoring from an average of 298 acres per year to an average of 932 acres per year between 2006 and 2013. In addition, the augmented survey effort helped identify and monitor 280 acres of new occupied KBB habitat. The KBB monitoring program is a key factor to successful restoration efforts given the data collected is used to focus management efforts in areas where there is a high probability of KBB occurrence and restoration success. Furthermore, participation by volunteers and partner organizations has cultivated public support for savanna management, which has been essential given the controversy surrounding the conversion of forest to savanna on a landscape scale.

In addition, the HMNF began several demonstration projects between 2008 and 2010 to determine the effectiveness of combining several types of mechanical treatments, prescribed burn prescriptions, and seeding/planting treatments to restore KBB habitat. Activities conducted for the demonstration project are covered in the Savanna/Barrens Restoration Project (USDA 2008b) and Savanna Ecosystem Restoration Project (USDA 2011b). By applying what is learned from small scale demonstration projects, the HMNF can make restoration treatments more efficient and cost effective. The HMNF also is working with Grand Valley State University, Michigan Technological University, University of Minnesota, and University of Southern Indiana to conduct other restoration studies to guide its adaptive management strategy. For example, the HMNF is working with Michigan Technological University and University of Minnesota to develop a habitat suitability model for the KBB and spatially explicit distribution models for the KBB and wild lupine to help identify high priority areas to target savanna restoration efforts within the BWC Ranger District. By using these models to identify areas with high restoration potential, the HMNF is refining its management strategy to recover the KBB.

The HMNF also is working to develop a management strategy that is responsive to climate change. The KBB Recovery Plan recommends providing for northward movement and managing savanna in the north end of the butterfly's range to help the species respond to climate change. Currently, the HMNF is working with 15 partner organizations and private landowners to restore savanna on over 5,500 acres of State, Federal, and private lands in west Michigan. The HMNF is conducting cooperative management activities with these partners to increase the size and connectivity of core habitat areas across different land ownerships. Coordinating treatments on a landscape scale would provide opportunities for the KBB and other savanna species to disperse northward across west Michigan in response to climate change. Studies have also shown that microclimate affects butterfly population dynamics including the KBB (Weiss et al 1993; Grundel et al 1998a; Grundel et al 1998b; Grundel and Pavlovic 2007; Willis and Bhagwhat 2009). Willis and Bhagwhat (2009) suggest heterogeneous habitats that provide "microclimatic buffering" zones within a location may serve as climatic refugia that may be essential for species to persist as

climate changes. To create climatic refugia, the HMNF is implementing prescriptions that create an interconnecting network of sub-habitats with variable light conditions (canopies with variable overstory and understory cover), topography (percent slope, aspect, and elevation), soil moisture, proximity to water bodies (uplands and lowlands), and plant communities. Using prescriptions that create a mosaic of variable sub-habitats would provide opportunities for KBB and other savanna species to respond to climate change by "moving in place" to utilize "microclimatic buffering" zones. For example, during hot dry summers, nectar plants in the shade may still be flowering in late-July, while those in open areas may senesce by mid-June.

Based on the distance sampling analyses, estimated minimum KBB abundance within the BWC District in 2013 (3,265-4,571) was 62% less than that reported in 2009 (8,962-10,333). The percentage of sites designated as "KBB present" also has declined within the District since 1997 (USDA 2013d). By implementing restoration activities at a landscape scale using an adaptive management approach that is responsive to climate change, as proposed under Alternatives 2 and 3, the HMNF would improve its probability of effectively reversing the negative trend in KBB populations. The HMNF's management efforts are beginning to improve the status of the KBB in other metapopulation areas. During inventory surveys conducted in 2013, four savanna conversion/restoration areas in the White River and Otto Metapopulation Areas were designated as occupied KBB subpopulations. An additional three savanna conversion areas were designated as occupied KBB subpopulations within the White River Metapopulation Area during inventory surveys in 2014. Other managed sites are expected to become occupied by the KBB in the near future given restoration activities are successfully increasing the percent cover of nectar plants and wild lupine. Although restoration areas are providing additional habitat for the KBB, the HMNF does not anticipate rapid colonization by the butterfly because a time lag in population response is expected. The HMNF is promoting colonization by locating restoration areas within dispersal distance of currently occupied KBB subpopulations and developing "living corridors" (i.e. corridors that provide wild lupine and other nectar plants for reproduction and foraging) between occupied and managed sites. Another indicator of the success of restoration activities is the documentation of more occurrences of other species that use openings and savannas within managed KBB subpopulations and savanna conversion areas including the red-headed woodpecker, Hill's thistle, prairie smoke, olive-sided flycatcher, eastern box turtle, Ottoe skipper, American woodcock, ruffed grouse, whip-poor-will, Blanding's turtle, and hill-prairie spittlebug (USDA 2013d).

It is also possible that favorable weather conditions may precipitate a recovery in KBB numbers given the percentage of sites designated as "present" in 2013 was similar to that observed in 2008. Favorable weather conditions can have a dramatic positive effect on KBB numbers, as demonstrated by the substantial increase documented between 2009 and 2010 (USDA 2013d). The observed increase in KBB numbers in 2010 was likely the result of warm spring and summer temperatures increasing overwinter survival of eggs and nectar availability.

The Direct and Indirect Effects of Implementing Alternative 1

Karner Blue Butterfly

Under Alternative 1, the quantity and quality of early successional vegetative types would continue to decline in the Project Area due to fire suppression and natural succession. As remnant openings, savannas, and barrens filled in with fire-intolerant woody and shade-tolerant herbaceous species, suitable KBB habitat would likely become scarcer as wild lupine and other important

KBB nectar plants are shaded-out or out-competed. Over time, extant KBB subpopulations would decrease in size and become more isolated and "living corridors" essential for promoting dispersal between subpopulations would decrease in size or in some cases disappear. Because landownership is fragmented within the Project Area and most of the documented occurrences of KBB occur on non-NFS lands, the future sustainability of the KBB population would rely on the cooperative management efforts of the HMNF and its partners to increase suitable KBB habitat around and between extant occupied sites across landownerships. In particular, connectivity between occupied sites on non-NFS lands is dependent on maintaining "living corridors" on NFS lands. Without cooperative restoration efforts, reductions in habitat quality and quantity within corridors and the openings, savannas, and barrens currently occupied by KBB would likely maintain the existing trend of decreasing population numbers within and adjacent to the BMA.

Alternative 1 would also not provide for the control of NNIP within remnant openings, savannas, barrens, or prairies within the Project Area. NNIP may reduce wild lupine and other native plants that provide nectar sources for adult KBB, which could decrease the numbers and distribution of KBB within the HMNF. Twenty-three NNIP were found within areas proposed for treatment during botanical surveys. Depending on the species and their abundance, invasive plants could shade out or out-compete, and subsequently replace, wild lupine and other important KBB nectar plants. Failure to successfully control invasive species would allow continued infestation and degradation of KBB habitat.

In addition, KBB habitat quantity and quality may decline under this alternative because it would maintain current road and trail densities, and thus human access and use of the Project Area. Some roads and trails within the Project Area provide suitable KBB habitat (i.e. wild lupine and other nectar plants grow along roadsides and some road-rut ponds provide "mud-puddling" opportunities for KBB to collect nutrients and minerals) and are either known to be occupied by KBB or provide "living corridors" that promote dispersal. Numerous oil/gas pipeline and power line right-of-ways intersect roads and trails within the Project Area and are commonly used travel routes by ORVs. Resource damage from unapproved recreational activities, the primary one being ORV use, has been documented within many of the openings, savannas, barrens, and prairies that occur within the Project Area, some of which have documented use by KBB. Dispersed camping sites also have degraded some occupied KBB habitat. In addition, horseback riding occurs on Forest Service roads and trails throughout the Project Area; cross-country travel is permitted for horseback riding, except where posted signs exclude this form of recreation. In some cases, this use, especially cross-country travel, has caused the degradation of suitable KBB habitat through trampling or horse consumption of native plants and the spread of invasive plants; and may have inadvertently killed KBB eggs or larvae.

Foot traffic, dispersed camping, horseback riding, and vehicle use along roads and trails and within adjacent open areas or right-of-ways may continue to damage or disturb KBB habitat (i.e. trampling, removing, or otherwise damaging wild lupine or other important nectar plants, and/or increasing NNIP); temporarily displace, alter movement, or disrupt normal behavior of KBB (i.e. interfere with "mud-puddling", dispersal or mating activities); or potentially harm or kill KBB from vehicle collisions, trampling KBB (all life stages), collection of KBB, and potential increases in wildfire starts. Use of roads and trails that are close to, or pass through, potential or occupied KBB habitat have the greatest potential to have these direct and indirect effects.

As KBB habitat quantity and quality decreases under Alternative 1, occurrences of KBB within subpopulations would likely decline within the Project Area. Surviving subpopulations would

become even more isolated and disconnected, and thus subject to a higher risk of extirpation from catastrophic events, such as wildfire. Without management, the HMNF would likely not meet the recovery goals for establishing a viable metapopulation in the BMA. Overall, Alternative 1 would continue to have adverse direct and indirect effects on KBB.

The Cumulative Effects of Implementing Alternative 1

Karner Blue Butterfly

Alternative 1 would not follow the guidance outlined in the Forest Plan for the restoration and maintenance of upland openings, savannas, barrens, and dry sand prairies within the HMNF. Openlands suitable for KBB and other early successional wildlife species are expected to decline on non-Federal lands within the MNF. Increases in human populations and associated land development, road construction, and recreational uses are expected on private lands. These activities would likely result in the degradation and permanent loss of habitat for KBB and other openland wildlife species and directly impact individuals by:

- Increasing habitat fragmentation, human disturbance, amount of bare ground, and soil erosion;
- Increasing the abundance and distribution of NNIP;
- Damaging wild lupine and other host plants, important KBB nectar plants, and other important plant species that provide food (foliage, nectar, or fruit) and/or cover, as well as other required habitat elements such as nesting, roosting, and/or hibernation sites;
- Temporarily displacing, altering movement, or disrupting normal behavior of KBB and other early successional wildlife species; and/or,
- Increasing the risk of vehicle/KBB collisions, wildfires, or visitors directly harming, harassing, or killing KBB (all life stages) and other wildlife species.

Additional actions performed on private lands that may adversely affect KBB and other wildlife species associated with openlands in the future within the MNF are fire suppression, mowing and grazing, ORV use, application of pesticides, and timber harvest. Mineral developments also are reasonably certain to occur in the foreseeable future within the MNF and have the potential to cumulatively affect KBB. In addition, private forest lands are expected to be further subdivided for residential and commercial development, which would likely reduce the amount of total forest cover and increase forest fragmentation. Although land development activities may increase non-forested areas on private lands within the MNF, the habitat conditions preferred by KBB and other wildlife associated with openlands are not likely to increase proportionately. For example, there is unlikely to be a proportionate increase in the host and nectar plants preferred by KBB.

Overall, habitat quantity and quality for the KBB and KBB occurrences would likely decline on private lands within the MNF boundary. As a consequence, managing for suitable KBB habitat on Federal lands within the MNF is likely to become more important in the future for the survival and recovery of the KBB. Under Alternative 1, the HMNF would not manage habitat for KBB on Federal lands or work in cooperation with other partner organizations that have been actively managing non-Federal lands to restore openlands for the KBB and other rare plants and animals. As a result, extant openlands occupied by KBB would continue to be isolated and lack connectivity, which would likely perpetuate the existing trend of decreasing KBB population numbers. Therefore, this alternative would have adverse cumulative effects on the KBB.

The Direct and Indirect Effects of Implementing Alternative 2

Karner Blue Butterfly

Approximately 93 acres of occupied KBB habitat occurs within Forest Service stands proposed for treatment under Alternative 2. An additional approximately 368 acres occurs adjacent to or within dispersal distance of areas that would be managed under Alternative 2.

Opening restoration/maintenance, opening creation, and savanna restoration proposed under Alternative 2 may have direct effects on KBB within the Project Area. Many of the areas that would receive opening restoration/maintenance, opening creation, and savanna restoration treatments have a history of use by KBB. Those stands that do not have documented occurrences of KBB are commonly located adjacent to or within dispersal distance of known KBB sites. A total of 134 acres of opening restoration/maintenance, 16 acres of opening creation, and 169 acres of savanna restoration contain occupied KBB sites, and 79 acres of opening restoration/maintenance, 10 acres of opening creation, and 202 acres of savanna creation are located adjacent to or within dispersal distance of occupied habitat. Areas proposed for opening restoration/maintenance, opening creation, or savanna restoration currently not occupied by KBB include remnant openings with savanna indicator plant species that provide potential KBB habitat, which may attract dispersers from adjacent occupied KBB sites. As treated openings, barrens, savannas, and prairies progress toward meeting objectives for vegetative cover and composition, KBB are likely to colonize these managed areas

Each of these proposed management activities would involve applying a series of treatments over the next decade to meet opening, savanna, or dry sand prairie objectives, with the order and intensity of treatments determined based on the results of effectiveness monitoring. Opening restoration/maintenance and opening expansion within remnant openings and savannas would involve using a combination of hand cutting (i.e. manual woody vegetation removal), mowing and slash/woody debris removal (i.e. mechanical woody vegetation removal), prescribed burning, herbicide treatment of woody vegetation and NNIP, soil scarification/site preparation, and native seeding/planting activities. These treatments would be used to meet the vegetative objectives for oak opening or oak savanna communities by reducing overstory and understory tree and shrub cover, promoting the growth of native grasses and wildflowers, minimizing the presence of NNIP, and protecting opening and savanna remnants. Opening restoration/maintenance within remnant dry sand prairies would involve using the same combination of treatments with the goal of meeting vegetative objectives for developing and protecting open native grassland communities. Alternatively, opening creation treatments to expand existing dry sand prairies would include timber harvest, in addition to hand cutting, mowing and slash/woody debris removal, prescribed burning, herbicide treatment of woody vegetation and NNIP, soil scarification/site preparation, and native seeding/planting activities. Many of the areas proposed for opening restoration/maintenance and opening expansion would be managed specifically to meet the habitat goals listed in the KBB Recovery Plan. Under Alternative 2, 108 acres of opening restoration/maintenance treatments and 21 acres of opening creation treatments would occur with the goal of meeting the vegetative objectives for providing suitable KBB habitat. All of the areas proposed for savanna restoration under Alternative 2would be managed to promote the development of viable KBB populations. Savanna restoration treatments would involve using a combination of timber harvest, hand cutting, mowing and slash/woody debris removal, prescribed burning, herbicide treatment of woody vegetation and NNIP, soil scarification/site preparation, and native seeding/planting activities. These treatments would be used to develop savanna habitat that

is suitable for KBB around and between existing KBB sites by reducing overstory and understory tree and shrub cover, promoting the growth of native grasses and wildflowers (especially wild lupine), minimizing the presence of NNIP, and protecting savanna remnants. Up to 485 acres of savanna restoration treatments would occur under Alternative 2. Successive treatments used during opening restoration/maintenance, opening creation, and savanna restoration have the potential to have direct effects on KBB during each entry, if KBB are present.

Opening restoration/maintenance, opening creation, and savanna restoration activities may displace or kill KBB within occupied sites or if adult KBB are dispersing from adjacent occupied areas. KBB have limited mobility and likely would not escape proposed management activities. While some KBB adults may be able to move out of treated areas, eggs and larvae are immobile and thus are particularly vulnerable and likely to be crushed during mechanical treatments such as mowing or disking, burned during prescribed burning, or trampled during hand cutting. Prescribed burns associated with opening and savanna restoration often need to be conducted during the growing season to meet the objectives of reducing woody vegetation and enhancing nectar plants. As a result, prescribed burning may directly affect KBB by killing all life stages. Except for prescribed burning associated with opening and savanna restoration, all management activities within occupied KBB sites would be prohibited between March 15 and August 15, which would minimize potential direct adverse effects on larval and adult life stages of KBB. However, these activities may still directly affect KBB by destroying overwintering eggs. None of the treatments proposed under Alternative 2 would include conducting timber harvest activities within occupied KBB habitat. Opening restoration/maintenance, opening creation, and savanna restoration activities, except for prescribed burning, proposed adjacent to or within dispersal distance of KBB sites would be prohibited during the KBB flight period (typically between May 10 and August 15, depending on the weather), which would minimize potential direct adverse effects on adult life stages of KBB.

Opening restoration/maintenance, opening creation, and savanna restoration also may damage or destroy wild lupine, reducing the availability of the sole food source for KBB caterpillars. KBB eggs and larvae primarily occur in association with wild lupine. As such, activities that damage or destroy wild lupine are more likely to destroy KBB eggs and larvae. Implementation of the proposed treatments may also temporarily disrupt the normal behavior of KBB, such as altering KBB dispersal or limiting the use of foraging or mating areas, potentially affecting productivity. KBB are most likely to be directly affected during the implementation of treatments by heavy equipment use (e.g. truck use, mowing, disking, plowing) and prescribed burning. In addition, vehicle use and foot traffic along roads and trails and within openings and right-of-ways during management activities may temporarily increase the level of disturbance, damage wild lupine and other nectar sources, temporarily displace, alter movement, or disrupt normal behavior of KBB, and increase the risk of vehicle collisions as described above in the No Action Alternative for existing use of the area.

Broadcast burning, commercial thinning, overstory removal, maintenance of in-stream structures, riparian planting, and road/stream crossing improvements proposed under Alternative 2, may also kill, displace, or disrupt the normal behavior of adult KBB dispersing from nearby or adjacent KBB sites within the Project Area. Although no occupied KBB subpopulations were located within areas proposed for these management activities during wildlife surveys, some of the Forest Service stands proposed for treatment occur adjacent to or within the KBB dispersal distance of openings, savannas, barrens, dry sand prairies, and right-of-ways that have a history of use by KBB. Specifically, occupied KBB sites are documented within several sections of open right-of-

ways that are located along the edges of, and therefore immediately adjacent to, four stands proposed for commercial thinning. Three of these stands also are proposed to be broadcast burned multiple times before and/or after timber harvest activities. In total, 225 acres of commercial thinning and 107 acres of broadcast burning would occur immediately adjacent to occupied KBB sites. An additional 427 acres of timber harvest, 329 acres of broadcast burning, and 17 acres of in-stream improvements would occur near or within dispersal distance of occupied KBB habitat. Similar to broadcast burning and commercial thinning, overstory removal would involve applying multiple treatments over the next decade to meet vegetative management objectives; these treated stands would be broadcast burned multiple times before and/or after timber harvest activities. Dispersing adult KBB may be directly affected by these management activities during each treatment entry. Remnant openings with savanna indicator plant species that provide potential KBB habitat are scattered within many of the stands proposed for these vegetative treatments, which may attract dispersers from nearby KBB sites. Commercial thinning and overstory removal would reduce overstory and understory cover to a greater or lesser degree. As stands become more open, the potential for KBB dispersers to enter treated units would increase. To meet management objectives, broadcast burns often need to be conducted during the growing season, and, as a result, may directly affect KBB by killing adults. However, except for broadcast burning, treatment activities associated with commercial thinning, overstory removal, maintenance of in-stream structures, riparian planting, and road/stream crossing improvements proposed adjacent to or within dispersal distance of KBB sites would be prohibited during the KBB flight period (typically between May 10 and August 15, depending on the weather), which would minimize potential direct adverse effects on adult life stages of KBB.

Timber harvests during savanna restoration, opening creation, commercial thinning, or overstory removal adjacent to KBB sites also could have direct effects on KBB by potentially creating ecological traps - habitat that animals perceive as high-quality, but instead acts as a population sink (Fuller 2008; USDI 2012; USDA 2013e). For example, creation of large tracts of savanna adjacent to occupied KBB subpopulations was followed by declining population numbers in the Albany Pine Bush Preserve and on lands managed by the Wisconsin Department of Natural Resources as individuals dispersed into newly opened areas (USDA 2013e). Because nectar plant cover was very low after savanna creation efforts in these areas, the newly opened areas provided low-quality habitat for the KBB and death rates exceeded birth rates (USDA 2013e). Creation of ecological traps within the Project Area would be particularly detrimental to recovery efforts given KBB subpopulations within the Project Area's boundaries are small, isolated, and at high risk for extirpation, and, thus, re-colonization of affected subpopulations would be unlikely. The potential for direct effects on KBB would be reduced by maintaining a minimum forested buffer of 50 meters around occupied KBB sites that are adjacent to timber harvests to reduce the potential of creating ecological traps within the Project Area (Fuller 2008; USDI 2012; USDA 2013e). Once suitable KBB habitat is established within stands proposed for savanna restoration or opening creation, "living corridors" would be developed via a combination of hand cutting, mowing and slash/woody debris removal, prescribed burning, herbicide treatment of woody vegetation and NNIP, soil scarification/site preparation, and native seeding/planting activities to promote dispersal from adjacent KBB subpopulations.

Management for KBB may be detrimental to the species if not planned and executed appropriately. The season, intensity, and frequency of management activities (particularly prescribed burns) could have detrimental effects on KBB through the killing of eggs, larvae, or adults. For example, operations during the larval and flight periods between March and August have the greatest potential of causing disturbance, damaging wild lupine and other nectar sources, and killing or

disrupting the behavior of KBB. While KBB adults and larvae are less likely to be affected directly by management activities conducted between September and April (outside the larval and flight periods), implementation of treatments may still have short-term adverse direct effects via the crushing or burning of eggs. In addition, restoration activities could eliminate a KBB subpopulation if they are conducted on the majority of an occupied KBB opening, and there is no source of individuals within a short distance to allow for repopulation. For example, prescribed burning may threaten KBB populations if burning is conducted on the majority of a KBB site at one time, and if high intensity fires are used at frequent intervals. Mowing between late spring and early summer could damage wild lupine, eliminating the food for KBB larvae, and mowing during adult nectaring periods may greatly reduce flower number and nectar availability. The mowing of wild lupine and nectar plants before seeds mature and disperse may reduce the reproduction of these food plants. This would have a long-term detrimental effect on KBB.

By implementing the conservation measures outlined for KBB in Appendix A, management for KBB would be planned and executed to minimize adverse effects on KBB adults, larvae, and eggs and wild lupine and other nectar sources. Conservation measures for occupied KBB habitat would be implemented in stands that have documented KBB occurrences (Table B2 in Appendix B). Should any new occupied KBB habitat be identified during treatment of units or in future surveys, these same conservation measures would be applied. Conservation measures for potential unoccupied KBB habitat would be implemented within stands proposed to be managed specifically to develop suitable KBB habitat, as well as treatment units that are adjacent to or within dispersal distance of KBB sites (Table A2 in Appendix A). Conservation measures include all Forest Plan Standards and Guidelines, as well as other suggested management practices described in the KBB Recovery Plan, the Draft Management Strategy, and the Final KBB 5-Year Review: Summary and Evaluation.

The HMNF will monitor treatment results and progress to allow for any necessary adjustments to be made to restoration techniques. For example, to minimize the number of KBB killed and the amount of suitable KBB habitat impacted from prescribed burns, occupied KBB openings would be divided into at least 3 burn units based on the number of KBB and habitat conditions (i.e. occurrence of wild lupine and other nectar sources), the most degraded 1/3 of the stand would be treated first, and no more than 1/3 of an occupied opening would be burned in any one year. In addition, occupied KBB openings scheduled for burning would ideally be within ¼ mile of unburned occupied KBB openings to aid re-colonization. Using an approximate 4 year burn frequency would also give the burned areas time to regenerate and become repopulated by KBB so they could aid in re-colonization when other units within occupied KBB openings are burned. Monitoring may indicate a burn frequency of longer than 4 years is needed to promote re-colonization given the time it takes for treated units to recover is expected to vary.

Except for prescribed burning and broadcast burning, all of the other vegetative management activities would be prohibited within KBB sites between March 15 and August 15, during the larval and flight periods. This would minimize adverse effects to KBB adults and larvae and important nectar plants such as wild lupine. Forest Service employees and contractors who perform management activities also would be educated to recognize and avoid wild lupine. In addition, annual surveys would be conducted to provide up-to-date information on distribution and status of KBBs, which would be applied to management activities to minimize adverse effects.

Some of the conservation measures outlined for occupied KBB habitat in Appendix A are not specified in the Forest Plan Standards and Guidelines, but are consistent with the management

suggestions proposed in the Standards and Guidelines, the KBB Recovery Plan, the Draft Management Strategy, and the Final KBB 5-Year Review: Summary and Evaluation. For example, these conservation measures allow a combination of manual or mechanical tree/shrub removal, herbicide use, and/or seeding/planting to occur following a prescribed burn on 1/3 of an occupied KBB opening, as long as all treatments occur within the burned unit, during the same year that the area was burned. By combining treatments, restoration goals for occupied KBB habitat may be achieved more efficiently and effectively. For example, a prescribed burn may remove leaf litter and reduce fire-intolerant species that out-compete important nectar plants like wild lupine, but only top kill woody vegetation <3 inches DBH. By following the burn with hand cutting, larger shrubs and trees could be removed that are not killed during the prescribed burn, increasing incident sunlight and subsequently favoring the establishment of fire-tolerant nectar species. In addition, the desired composition of nectar plants may be achieved more efficiently and effectively by broadcast seeding burned areas in the fall. Also, some NNIP, such as autumn olive or Japanese barberry, may be controlled more efficiently and effectively by following a prescribed burn with herbicide application. Although this conservation measure was not specified in the Forest Plan Standards and Guidelines, it is consistent with the Standards and Guidelines given that the conservation measures for subsequent restoration techniques would be implemented. Minimal additional adverse effects to KBB or suitable KBB habitat would be likely to occur within the stands since: 1) they would have already been burned; 2) no more than 1/3 of an occupied site would have been treated within a given year; and, 3) the treatments would occur in the most degraded portions of occupied sites.

Another conservation measure outlined for occupied KBB habitat in Appendix A that is not specified in the Forest Plan Standards and Guidelines allows trucks with trailers to be used to remove slash/woody debris within an occupied KBB opening. This measure is consistent with the management suggestions proposed in the Standards and Guidelines, the KBB Recovery Plan, the Draft Management Strategy, and the Final KBB 5-Year Review: Summary and Evaluation. Mechanical removal of slash/woody debris would be prohibited between March 15 and August 15, and would occur on no more than half of an occupied KBB opening each season unless there is a colonization source within 1/4 mile that has the capability to recolonize the opening. Cut vegetation within an occupied KBB opening that may contain KBB eggs would be left unless the cut vegetation is collected and placed in another suitable KBB habitat site. In occupied KBB openings that have experienced heavy woody encroachment, it is logistically unfeasible to remove slash/woody debris by hand after woody vegetation has been cut. By allowing the use of a truck and trailer, the conservation measure requiring slash not to exceed 20% of an area would be achieved more efficiently and effectively. This conservation measure is consistent with the Forest Plan Standards and Guidelines given that the adverse effects of removing slash/woody debris using a truck and trailer are assumed to be similar to those from mowing, and, as such, the conservation measures outlined for mowing in Appendix A would be applied.

When management is planned and executed appropriately (i.e. conservation measures in Appendix A are implemented), prescribed burning and mechanical treatments within occupied KBB habitat have been shown to not adversely affect KBB or wild lupine. For example, Pickens (2006) compared KBB abundance in burned, mowed, and unmanaged sites and found no significant difference in male or female abundance during the first brood. In the second brood, there were significantly more females in burned areas compared to the other two treatments, and significantly more males in burned and mowed areas compared to unmanaged areas (Pickens 2006). In addition, King (2003) compared control, mowed, and burned treatment effects on KBB populations and the cover of associated herbaceous plants, and found no treatment-related changes

in KBB density or cover of wild lupine. Wild lupine responses also did not significantly differ among herbicide and mechanical treatments applied at annual, 4, and 8 year intervals in a study conducted by Forrester et al (2005). However, wild lupine cover, clump size, and density of stems per clump increased following application of treatments in general (Forrester et al 2005). The number and cover of nectar species, total herbaceous cover, and species richness also responded positively to treatment overall (Forrester et al 2005). Also, lupine abundance and the proportion of lupine stems with signs of feeding were positively correlated with military training activities, suggesting that maintenance of lupine habitat can be achieved with human uses such as military training when planned and executed appropriately (Smith et al 2002). In general, many methods for removing and suppressing tree and shrub canopy can have a net positive effect on wild lupine and KBB, and should be timed and carried out in ways that minimize harm to the butterfly, wild lupine, and nectar plants. Given KBB subpopulations are small, isolated, and lack connectivity within the Project Area, using appropriate return intervals is essential to promote opportunities for re-colonization within managed sites.

Under Alternative 2, strip/patch or spot application of glyphosate, triclopyr, or imazapic is proposed on up to 100 acres to control NNIP and persistent woody vegetation within opening restoration/maintenance, opening creation, and savanna restoration areas. Additional herbicide treatment of NNIP is proposed on 108 acres. Ecological risk assessments conducted for glyphosate, triclopyr, and imazapic suggest that use at rates commonly used by the Forest Service poses little or no risk to wildlife, as long as they are used in accordance with the manufacturer label and formulations labeled for use in aquatic areas for glyphosate and triclopyr are used within 100 feet of wet areas such as lakes, wetlands, and riparian corridors (USDA 2004b; USDA 2011c; USDA 2011d). The proposed herbicides are not highly toxic to insect species (USDA 2004b; USDA 2011c; USDA 2011d). Proposed herbicides are not cholinesterase inhibitors such as organophosphate or a carbamate insecticide (or chemically related to such insecticides) that are highly toxic to wildlife, especially insects and other invertebrates. Nor are the proposed herbicides chemically related to neonicotinoids such as clothianidin that are highly toxic to bumble bees and other invertebrates, or to chlorinated hydrocarbon insecticides such as DDT that are highly persistent in the environment.

In addition, glyphosate, triclopyr, and imazapic are not expected to bioaccumulate in the food chain (USDA 2004b; USDA 2011c; USDA 2011d). KBB could be exposed to herbicides by direct contact with herbicide spray or with recently treated foliage. Oral exposure also could occur by ingesting contaminated nectar or by drinking from water sources that have received contaminated surface runoff. However, KBB are not likely to come in direct contact with herbicide spray or recently treated foliage, or consume contaminated nectar or water because only strip/patch or spot application of herbicides would be used to treat small areas within occupied KBB habitat. Research to date suggests that glyphosate can be used with minimal direct impact on KBB (USDI 2003). Sucoff et al. (2001) suggested that glyphosate-triclopyr mixtures may cause a slight (2%) reduction in the reproductive success of KBB.

Poorly timed or poorly located use of herbicides can have a negative effect on KBB, by killing or suppressing wild lupine or important nectar plants (USDI 2003). Application of herbicides in KBB occupied areas is best done after wild lupine and nectar plants senesce (USDI 2003). Any adverse effects to KBB and its habitat would be minimized by prohibiting herbicide application in or adjacent to occupied KBB habitat between April 1 and August 15, and by marking and avoiding wild lupine during herbicide application, as outlined in the conservation measures for KBB in Appendix A. Herbicide application adjacent to occupied KBB habitat could occur between April 1

and August 15 only when the wind is not blowing toward the occupied habitat and there is a minimum buffer of 660 feet (200 meters) between the habitat and treatment area. These conservation measures would ensure that herbicide applications are not completed at a time and place where there would have adverse effects to the species (USDA 2006a; USDI 2006).

Vegetative management proposed under Alternative 2 would likely have a greater positive effect on local KBB populations than through habitat change under the No Action Alternative. Implementation of treatments may temporarily reduce densities of wild lupine and other native flowering plants that serve as food sources for KBB larvae and adults, and/or the cover of warm season grasses that are used by adult KBB for basking and roosting. For example, prescribed burns may damage vegetation and increase the amount of bare ground within treated KBB sites, temporarily decreasing cover and the abundance of native grasses, herbs, wildflowers, and fruit-bearing shrubs. In addition, mechanical equipment such as a mower or truck and trailer may run over and destroy ant mounds during operations, which may subsequently increase the rates of parasitism and predation on KBB larvae. Without sufficient knowledge of what plant species are present on a given site and their response to different management activities, implementation of proposed treatments may increase undesired plant species. For example, fire may either increase the abundance of invasive species, such as spotted knapweed, and/or native species, such as Pennsylvania sedge, that compete with wild lupine and nectar plants.

Disturbance from restoration activities also may create conditions favorable for the establishment of NNIP, such as spotted knapweed and common St. John's-wort. While non-natives like spotted knapweed do provide nectar sources for KBB, they tend to choke out some native plants, and consequently dominate and reduce overall site biodiversity, which may increase the risk of extirpation of KBB subpopulations (USDI 2006). Proposed NNIP treatments under Alternative 2 would minimize the occurrence of non-natives and favor more desirable native nectar species. Effects of herbicides on the growth and flowering of wild lupine and other nectar plant species varies, and at times may result in a temporary reduction in habitat quantity and quality for KBB (USDI 2003). Potential adverse indirect effects to KBB habitat quality are expected to be minimized by implementing the conservation measures outlined for KBB in Appendix A, which maximize habitat recovery potential, minimize incidental habitat damage due to equipment or methodology, and use pre- and post-treatment monitoring to ensure treatments are efficient and effective.

Under Alternative 2, opening restoration/maintenance, opening creation, savanna restoration, and overstory removal also may improve habitat for herbivores occurring within the Project Area. Wild lupine is browsed by deer, woodchucks, and insects (USDI 2003). In particular, deer may experience an increase in habitat quantity and quality, potentially causing localized increases in deer numbers and increased herbivory on wild lupine within areas being managed for KBB in the Project Area (USDI 2006). KBB eggs and larvae primarily occur in association with wild lupine, so herbivory on wild lupine also likely would destroy KBB eggs and larvae. High deer densities can devastate KBB habitat and cause direct mortality by the ingestion of larvae (Schweitzer 1994). Schweitzer (1994) recommends that deer populations be managed to levels where no more than 15 percent of lupine flowers are consumed. However, the management of deer populations is outside Forest Service jurisdiction and authority. In the long-term, deer herbivory may decrease the overall rate of KBB reproduction by limiting lupine growth. It is unknown whether other birds or mammals that may benefit from opening restoration/maintenance, opening creation, savanna restoration, and overstory removal treatments such as wild turkey cause significant mortality at

any life stage of KBB. However, bird beak-marks have been observed occasionally on the wings of adult KBB (USDI 2003).

Much of the habitat change expected from opening restoration/maintenance, opening creation, and savanna creation treatments proposed under Alternative 2 would likely have beneficial indirect effects to local KBB populations. Prescribed burning would be used to suppress undesirable plant species, enhance the diversity and abundance of native forbs and grasses, raise soil pH, and expose mineral soils. Woody plant cover would be reduced, increasing the incident sunlight at ground level. Hand cutting, mowing, and herbicide application would mimic certain effects of fire, wild herbivore grazing and browsing, and insect and disease outbreaks, suppressing undesirable herbaceous and woody plants and increasing incident sunlight at ground level. Soil scarification/site preparation would mimic certain effects of fire by exposing mineral soils and providing sunlit seed beds to promote the germination and growth of lupine and nectar plants. Soil scarification/site preparation would be used when native nectar plant and/or grass densities are insufficient to meet vegetative management objectives for openings, savannas, dry sand prairies, and/or suitable KBB habitat, and would be followed by seeding or planting. Depending on the species mix included, seeding/planting activities would potentially increase the abundance of the KBB's host plant, adult nectar sources, and warm season grasses for basking and roosting. Herbicide treatments also would reduce stump sprouting of woody vegetation and establishment of NNIP within treated areas, which could impede the establishment of wild lupine and other desired nectar sources through shading or competition.

Opening restoration/maintenance, opening creation, and savanna restoration would reduce overstory and understory cover, and increase sunlight and the overall open nature of opening, savanna, and dry sand prairie habitats within the Project Area. These treatments would subsequently shift the competitive advantage away from shade-tolerant plant species and provide the variable light conditions required to promote the growth of wild lupine, other KBB nectar plants such as black-eyed Susan and horsemint, and native grasses such as big blue stem, little blue stem, and Indian grass (*Sorghastrum nutans*). The expected net effect of opening restoration/maintenance, opening creation, and savanna restoration would be improved habitat conditions for KBB, specifically within areas managed to meet the habitat goals listed in the KBB Recovery Plan and the Draft Management Strategy. This would be evidenced by increased production and biomass of wild lupine and other important KBB nectar plants and the suppression of woody vegetation. These improved habitat conditions would likely increase adult foraging and breeding, and the development of eggs and larvae.

Currently, KBB habitat occupies 884 acres within the Project Area with the majority (88%) located on non-NFS lands. Without management, the quantity and quality of this habitat would continue to decline over time due to uncontrolled encroachment of woody vegetation and subsequent reductions of wild lupine and other nectar plants. Opening restoration/maintenance, opening creation, and savanna restoration activities would create up to 614 acres of suitable KBB habitat under Alternative 2. This acreage would contribute to the Forest Plan's goal to restore 20,300 acres of savannas/barrens within designated KBB metapopulation areas and essential KBB habitat.

Specifically, Alternative 2 would include treating 156 acres of NFS lands that were identified in the Newaygo Prairies Conservation Action Plan (Legge and Pearsall 2009) as priority areas to include in future NEPA to facilitate cooperative management activities with adjacent landowners. These acres were identified as being particularly important to enable cooperative prescribed

burning. By proposing savanna restoration on these acres, Alternative 2 would cultivate more opportunities to work with adjacent landowners to promote the expansion of existing KBB subpopulations across landscapes and jurisdictional boundaries.

Management activities under Alternative 2 would create a heterogeneous habitat mosaic that provides sub-habitat variation in tree canopy and shrub cover, plant community composition, thermal environment, topography, and soil moisture required for mating, roosting, adult feeding, oviposition (i.e. egg laying), and egg and larval growth and survival. By creating a mosaic of variable sub-habitats, Alternative 2 would also provide opportunities for KBB to respond to climate change by "moving in place" to utilize "microclimatic buffering" zones. In addition, this alternative would develop a habitat design that maximizes connectivity between sub-habitat types within subpopulations, as well as between subpopulations within and adjacent to the BMA. This would meet the requirement to promote dispersal and support persistent viable metapopulations. By creating a heterogeneous habitat mosaic that provides sub-habitat variation for all KBB life stages and maximizes connectivity between sub-habitat types within and between KBB subpopulations, Alternative 2 would increase the acreage, distribution, and connectivity of suitable KBB habitat as directed by the KBB Recovery Plan, the Draft Management Strategy, and the Forest Plan. Alternative 2 would also follow an adaptive management approach, modifying treatments in response to effectiveness monitoring and using demonstration projects to determine the most efficient and effective restoration techniques. This would increase the probability of restoration success within the Project Area. As management activities increase the amount of suitable KBB habitat around and between extant subpopulations and increase dispersal opportunities between occupied and unoccupied habitat patches, the number of occupied KBB subpopulations and the total number of KBB within and adjacent to the BMA would likely increase.

Overall, vegetation management activities proposed under Alternative 2 may have direct and indirect effects on KBB within the Project Area. However, opening restoration/maintenance, opening creation, and savanna restoration are necessary to preserve, enhance, and create habitat for KBB to promote persistent populations within and adjacent to the BMA. Without these treatments, KBB populations would likely continue to decline within the Project Area, and surviving subpopulations would become even more isolated and disconnected, and thus subject to a higher risk of extirpation from catastrophic events. Opening restoration/maintenance, opening creation, and savanna restoration are expected to have an overall beneficial effect on KBB populations by increasing the acreage, distribution, and connectivity of suitable habitat with the goal of establishing a large viable metapopulation in the Bigelow Metapopulation.
ORV use, cross-country travel via foot or horseback, and dispersed camping may increase within areas proposed for opening restoration/maintenance, opening creation, and savanna restoration under Alternative 2 resulting in the same effects as those described for these activities under the No Action Alternative.

Potential adverse effects would be minimized with the implementation of the conservation measures outlined for KBB in Appendix A. Signs would be installed within KBB sites and areas managed to provide suitable KBB habitat explaining the benefits of restoring native plant communities, and requesting visitors to stay on roads and trails and to camp outside of occupied KBB habitat. If damage from human activities is noted within KBB sites or areas managed to provide suitable KBB habitat, additional steps may be taken to limit the potential for resource damage, including, but not limited to, temporary closure orders or the installation of physical barriers (e.g. barrier posts, gates, or piling brush around the perimeter of treatment areas).

In addition to such habitat protection measures, under Alternative 2, activities to repair resource damage (i.e. site rehabilitation via removal of NNIP and trash, and seeding/planting activities), and transportation management activities (i.e. road closures, road construction, road reconstruction) would be implemented to reduce environmental impacts from existing human use within the Project Area. Habitat protection measures would be implemented on up to 932 acres under Alternative 2 to manage potential adverse effects from existing human activities within areas proposed for opening restoration/maintenance, opening creation, and savanna restoration. Treatments to repair resource damage within openings, barrens, savannas, and dry sand prairies also would occur on 147 acres under Alternative 2, of which 51 acres currently contain occupied KBB sites and 43 acres occur adjacent to or within dispersal distance of occupied KBB habitat. In addition, road system activities would take place to limit motorized access to sensitive habitats and areas by reducing the amount of unclassified roads, roads which are not open to public use, in the Project Area. Under Alternative 2, 3.9 miles of existing Forest Service roads that are currently open to the public would be closed. Approximately 1 mile of Forest Service roads occurs adjacent to or within occupied KBB habitat, of which 0.4 miles would be closed under this alternative. To improve access to stands for treatment activities, Alternative 2 proposes constructing 1.0 mile of new Forest Service roads and reconstructing 6.2 miles of Forest Service and County roads. Road construction and reconstruction activities would occur within one occupied KBB site, including construction of approximately 100 feet of Forest Service road and reconstruction of approximately 600 feet of County road. As a result, a maximum of 0.24 acres of KBB habitat would be removed.

Given many of these management activities would occur in, adjacent to, or within dispersal distance of KBB sites, the proposed treatments may have direct and indirect effects on KBB. Implementing habitat protection measures, addressing resource damage, and transportation management activities may displace or kill KBB within currently occupied sites, adult KBB dispersing from adjacent occupied areas, or KBB within future newly colonized areas. Road construction, road reconstruction, and road closure activities also may displace or kill KBB that are “mud-puddling”, feeding upon nectar plants, or otherwise dispersing along road corridors. In addition, these management activities may damage or destroy wild lupine, reducing the availability of the sole food source for KBB caterpillars and potentially destroying KBB eggs and larvae. Implementation of the proposed treatments may also temporarily displace, alter the movement, or disrupt the normal behavior of KBB, such as altering KBB dispersal or limiting the use of foraging or mating areas, potentially affecting productivity. Habitat protection, resource damage, road closures, and road construction/reconstruction activities proposed within occupied KBB sites would be prohibited between March 15 and August 15. Those that occur adjacent to or within dispersal distance of occupied KBB sites would be prohibited during the KBB flight period (typically between May 10 and August 15, depending on the weather). Timing restrictions would minimize potential direct adverse effects on larval and adult life stages of KBB. However, actions within occupied sites may still directly affect KBB by destroying overwintering eggs.

Habitat protection, addressing resource damage, road closures, and road construction/reconstruction may indirectly effect KBB within the Project Area by temporarily reducing densities of wild lupine and other native flowering plants that serve as food sources for KBB larvae and adults, and/or the cover of warm season grasses that are used by adult KBB for basking and roosting. These management activities also may destroy ant mounds during operations, which may subsequently increase the rates of parasitism and predation on KBB larvae. In addition, disturbance from implementing habitat protection measures, addressing resource damage, and managing the transportation system may introduce NNIP and/or create conditions

favorable for the establishment of NNIP, such as spotted knapweed, and/or undesirable native species, such as Pennsylvania sedge, that compete with wild lupine and nectar plants. Potential adverse indirect effects to KBB habitat quality are expected to be minimized by implementing the conservation measures outlined for KBB in Appendix A.

Implementation of habitat protection measures, activities to repair resource damage, and transportation management activities would have primarily beneficial effects to local KBB subpopulations within the Project Area by reducing conflicts between human use and restoration and maintenance of KBB habitat. By implementing these treatments, human use would be less likely to kill or displace KBB; damage or disturb KBB habitat; temporarily displace, alter movement, or disrupt normal behavior of KBB; and potentially reduce the incidents of wildfires. Treatments to rehabilitate and protect areas of resource damage within or adjacent to KBB sites would increase the diversity and abundance of native forbs and grasses. Closure of roads within or adjacent to areas proposed for opening restoration/maintenance, opening creation, and savanna restoration treatments would likely experience an increase in nectar plant availability, increasing the quality and quantity of KBB dispersal corridors within the Project Area.

Human use and its associated impacts (i.e. damaging wild lupine or other habitat elements, killing or disrupting the behavior of individual KBB, spreading NNIP, soil disturbance or compaction) would continue to adversely affect KBB where County roads and Forest System roads remain open to motorized use within potential and occupied KBB habitat. Potential adverse effects from roads that would remain open would be minimized with the implementation of conservation measures outlined for KBB habitat in Appendix A. Signs would be installed along roads that occur within KBB sites and areas managed to provide suitable KBB habitat explaining the benefits of restoring native plant communities and requesting visitors to stay on roads and trails and to camp outside of occupied KBB habitat. If damage from ORV use is noted within KBB sites or areas managed to provide suitable KBB habitat, additional steps may be taken to limit the potential for resource damage, including, but not limited to, temporary closure orders and the installation of physical barriers.

Under Alternative 2, horseback riding would continue to occur as described in the No Action Alternative. Because of their weight to small area of contact with ground, horses have a relatively high potential for environmental damage (Landsberg et al 2001). Horse use has been shown to result in soil erosion and compaction (Cole and Spildie 1998; Deluca et al 1998; Campbell and Gibson 2001; Pickering et al 2009). In addition, horse use has been shown to damage forbs and shrubs via trampling and grazing, and cause defoliation and nutrient enrichment by urination and defecation, reducing plant height and biomass and changing plant species composition along trails (Cole and Spildie 1998; Pickering et al 2009). Studies also have shown that horses can transport the seeds of NNIP in their manure and thus have the potential to spread invasive species (Campbell and Gibson 2001; Landsberg et al 2001; Cosyns et al 2005; Wells and Lauenroth 2007; Pickering et al 2010; Stroh and Struckhoff 2009; Pickering and Mount 2010). The risk of invasive species establishment is highest when manure is deposited in disturbed, damp sites, especially off-track (Landsberg et al 2001).

Horse use has also been reported as a contributing factor in the decline of several invertebrate species. Vaughan and Black (2002) reported that within one site occupied by the Taylor's checkerspot butterfly, 15-16 horses trampled much of the area containing Indian paintbrush (*Castilleja indivisa*) (the larval host plant) and may have played a role in the extirpation of the Taylor's checkerspot from the site. Recreation also has been found to disrupt the normal behavior

of KBB and other listed butterfly species, potentially reducing availability of suitable habitat and reducing productivity. Hiking, jogging, and dog walking along trails in occupied KBB habitat at Indiana Dunes National Lakeshore was found to significantly disturb KBB (Bennett 2010). Post-disturbance female KBBs flew for longer periods of time than male KBBs before returning to natural behavior, such as ovipositing, nectaring, host plant searching behavior and basking (Bennett et al 2010). Empirical data suggests that if female KBB are frequently disturbed, they select host plants farther from trails, essentially degrading the quality of KBB habitat in proximity to trails and reducing the total amount of suitable habitat available to females (Bennett et al 2010). These results have implications for female KBBs in terms of energy expenditure (potentially impacting their survival and egg production), their oviposition rate (potentially decreasing the number of eggs laid over an individual's flight period), and host plant selection (potentially limiting females from ovipositing on lupines near trails).

Potential adverse effects from cross-country travel and horseback riding within potential and occupied KBB habitat in the Project Area would be minimized by installing signs explaining the benefits or restoring native plant communities and requesting visitors to stay on roads and trails and to camp outside of occupied KBB habitat. If damage from human activities is noted with KBB sites or areas managed to provide suitable KBB habitat, additional steps may be taken to limit the potential for resource damage, including, but not limited to, temporary closure orders and the installation of physical barriers.

Overall, habitat protection, resource damage, and transportation management activities proposed under Alternative 2 would likely decrease the risk of mortality and improve habitat quantity and quality for KBB within the Project Area. Because Alternative 2 proposes an additional 1.1 miles of Forest Service road closures, as compared to Alternative 3, it would reduce the potential for human access and use to impact newly created or restored openings and savannas more than Alternative 3.

The Cumulative Effects of Implementing Alternative 2

Karner Blue Butterfly

The cumulative effects of activities on non-Federal lands on the KBB and its habitat would be the same as those described under the No Action Alternative. Because habitat quantity and quality for the KBB and KBB occurrences are expected to decline on private lands within the MNF boundary, managing for suitable habitat on Federal lands is essential to promote viable populations.
The Forest Plan directs restoration and maintenance of 20,300 acres of savanna/barrens within designated KBB population management areas and essential KBB habitat within the HMNF. Within the BMA, 526 acres are proposed to be treated on NFS lands to develop savanna/barrens and openings that are accessible and usable by KBB (USDA 2004a). Given only 18% (1,652 acres out of 9,421 acres) of the BMA is on NFS lands, conducting cooperative management activities with adjacent landowners are critical to achieving recovery goals for the KBB (USDA 2004b; Legge and Pearsall 2009). Opening restoration/maintenance, opening creation, and savanna restoration treatments proposed under this Project would not only help achieve the restoration target of 536 acres on NFS lands, but also promote habitat restoration for KBB and other savanna-dependent species across landscapes and jurisdictional boundaries. Over the last two decades, non-profit organizations, local and state government agencies, and private landowners have been actively managing over 750 acres to restore oak-pine savannas for the KBB and other plants and animals dependent on this rare ecosystem. Under Alternative 2, the HMNF would work in

cooperation with these partners to conduct coordinated management activities, particularly prescribed burning, to maximize increases in total KBB habitat creation and connectivity across different land ownerships. However, Alternative 2 would cultivate more opportunities to work with adjacent landowners than Alternative 3 since it would include treating an additional 156 acres of NFS lands that are adjacent to several large KBB restoration areas being managed by other landowners. Implementation of the conservation measures presented in Appendix A would minimize potential adverse effects to KBB and its habitat on NFS lands within the Project Area. Although increases in human populations and associated land uses and developments are expected within the MNF in the future, positive effects of Forest Service projects such as the Proposed Action should mitigate potential the negative effects of activities on private lands.

Over the next 50 years, stands proposed for treatment under Alternative 2 would regenerate and mature, again favoring wildlife species that prefer mature forest types. However, based upon management direction in the Forest Plan, reversion to pre-treatment conditions would be prevented as vegetation management would continue to occur within the MNF in the future. Stands restored to savanna/barrens and openings would be maintained as such before they converted to other forest types, thus continuing to provide suitable KBB habitat. Overall, the net long-term cumulative effect of the proposed restoration treatments and other protective measures and planned activities within the MNF would be beneficial to the KBB.

The Direct and Indirect Effects of Implementing Alternative 3

Karner Blue Butterfly

The direct and indirect effects of Alternative 3 would be essentially the same as those described for Alternative 2 with the following exceptions. Approximately 93 acres of occupied KBB habitat occurs within stands proposed for treatment under Alternative 3. An additional approximately 368 acres occurs adjacent to or within dispersal distance of areas that would be managed under this alternative.

Opening restoration/maintenance, opening creation, and savanna restoration proposed under Alternative 3 would have the same direct and indirect effects on KBB within the Project Area, as described under Alternative 2. The only difference between Alternative 2 and 3 is that 485 acres of savanna restoration treatments would occur under Alternative 2, while only 329 acres of savanna restoration treatments would occur under Alternative 3. Therefore, less acres of savanna restoration and its associated impacts would occur under Alternative 3. Specifically, Alternative 3 would not include treating 156 acres of NFS lands that were identified in the Newaygo Prairies Conservation Action Plan (Legge and Pearsall 2009) as priority areas to include in future NEPA to facilitate cooperative management activities with adjacent landowners. These acres were identified as being particularly important to enable cooperative prescribed burning. By not proposing savanna restoration on these acres, Alternative 3 would not cultivate as many opportunities to work with adjacent landowners to promote the expansion of existing KBB subpopulations across landscapes and jurisdictional boundaries.

Opening restoration/maintenance, opening creation, and savanna restoration activities would create up to 614 acres of suitable KBB habitat under Alternative 2 and up to 458 acres of suitable KBB habitat under Alternative 3. Both acreages would contribute to the Forest Plan's goal to restore 20,300 acres of savannas/barrens within designated KBB metapopulation areas and essential KBB habitat (USDA 2012c).

Overall, vegetation management activities proposed under Alternatives 2 and 3 may have direct and indirect effects on KBB within the Project Area. However, opening restoration/maintenance, opening creation, and savanna restoration are necessary to preserve, enhance, and create habitat for KBB to promote persistent populations within and adjacent to the BMA. Without these treatments, KBB populations would likely continue to decline within the Project Area, and surviving subpopulations would become even more isolated and disconnected, and thus subject to a higher risk of extirpation from catastrophic events. Opening restoration/maintenance, opening creation, and savanna restoration are expected to have an overall beneficial effect on KBB populations by increasing the acreage, distribution, and connectivity of suitable habitat with the goal of establishing a large viable metapopulation in the BMA as directed by the KBB Recovery Plan, the Draft Management Strategy, and the Forest Plan.

Under Alternatives 2 and 3, activities to repair resource damage (i.e. site rehabilitation via removal of NNIP and trash, and seeding/planting activities), and transportation management activities (i.e. road closures, road construction, road reconstruction) would be implemented to mitigate and reduce environmental impacts from human use within the Project Area. Habitat protection measures would be implemented on up to 932 acres under Alternative 2 and on up to 700 acres under Alternative 3 to manage potential adverse effects from human activities within areas proposed for opening restoration/maintenance, opening creation, and savanna restoration. Alternatives 2 and 3 would provide for the implementation of habitat protection measures on all KBB sites and areas managed to provide suitable KBB habitat within the Project Area. Like Alternative 2, treatments to repair resource damage within openings, barrens, savannas, and dry sand prairies also would occur on 147 acres under Alternative 3, of which 51 acres currently contain occupied KBB sites and 43 acres occur adjacent to or within dispersal distance of occupied KBB habitat. In addition, road system activities would take place to limit motorized access to sensitive habitats and areas by reducing the amount of unclassified roads, roads which are not open to public use, in the Project Area. Under Alternative 2, 3.9 miles of existing Forest Service roads that are currently open to the public would be closed, while 2.8 miles of Forest Service roads would be closed under Alternative 3. Approximately 1 mile of Forest Service roads occurs adjacent to or within occupied KBB habitat, of which 0.4 miles would be closed under both alternatives. To improve access to stands for treatment activities, Alternatives 2 and 3 propose constructing 1.0 mile of new Forest Service roads and reconstructing 6.2 miles of Forest Service and County roads. Both alternatives would remove a maximum of 0.24 acres of occupied habitat within one KBB site via the construction of approximately 100 feet of Forest Service road and reconstruction of approximately 600 feet of County road.

Implementation of habitat protection measures, activities to repair resource damage, and transportation management activities, under Alternatives 2 and 3, would have primarily beneficial effects to local KBB subpopulations within the Project Area by reducing conflicts between human use and restoration and maintenance of KBB habitat.

Overall, although habitat protection, resource damage, and transportation management activities proposed under Alternatives 2 and 3 may have direct and indirect effects on KBB, these actions would likely decrease the risk of mortality and improve habitat quantity and quality for KBB within the Project Area over the long-term. Both alternatives would equally reduce potential adverse effects of human access and use to KBB and its habitat given they propose the same activities within or adjacent to existing KBB sites. However, because Alternative 2 proposes an additional 1.1 miles of Forest Service road closures, it would reduce the potential for human access and use to impact newly created or restored openings and savannas more than Alternative 3.

The Cumulative Effects of Implementing Alternative 3

Karner Blue Butterfly

Cumulative effects under Alternative 3 would be essentially the same as those described under Alternative 2. However, Alternative 2 would cultivate more opportunities to work with adjacent landowners since it would include treating an additional 156 acres of NFS lands that are adjacent to several large KBB restoration areas being managed by other landowners. Overall, the net long-term cumulative effect of the proposed restoration treatments and other protective measures and planned activities within the MNF would be beneficial to the KBB.

Northern Long-Eared Bat - Status and Distribution

The northern long-eared bat has been proposed to be federally listed as an endangered species under the ESA. Proposed activities under Alternatives 2 and 3 would occur within potential breeding habitat for the northern-long eared bat on the HMNF. During the summer months, northern long-eared bats roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees. This species typically uses intact, cluttered, interior and mature forests for roosting. Male and non-reproductive females may roost in cooler places such as caves and mines. Northern long-eared bats are not species specific when selecting roost trees, they chose tree species based on their ability to retain bark or provide cavities or crevices. Any tree providing these characteristics, with a DBH >3 inches has the potential be a roost tree. In Michigan, this species commonly roosts in deciduous trees. The northern long-eared bat forages through the understory of forested hillsides and ridges feeding on terrestrial and aquatic insects after dusk, using echolocation. Detailed information on the ecology on the northern long-eared bat in the Eastern Region can be found in the Northern Long-Eared Bat Interim Conference and Planning Guidance (USDI 2014).

The northern long-eared bat can be found throughout its range (Figure 3-7) during summer months, but is more common in the northern portion of its range. There are many factors that can be used to determine presence or absence of the species within in its range, such as availability of suitable habitat and time of year. The Tippy Dam, located on the Manistee Ranger District of the HMNF, provides winter habitat for the northern long-eared bat. This is the only known winter roost on the HMNF and it is greater than 50 miles north of the Project Area. Although there are no known foraging or roosting sites used by the northern long-eared bat within the Project Area, their presence is assumed during the summer. The northern long-eared bat was found in Wexford County during surveys in 2014 (George and Kurta 2014) and likely occurs throughout the MNF.

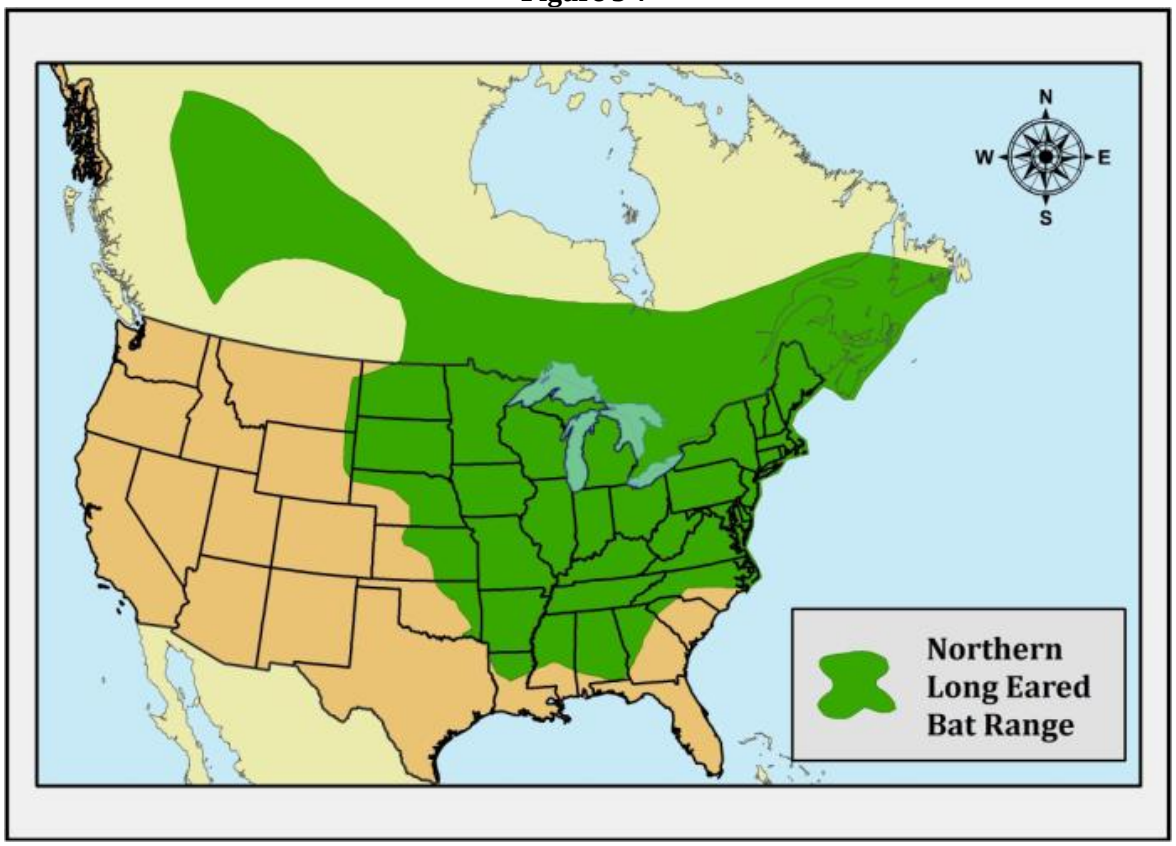
The Direct and Indirect Effects of Implementing Alternative 1

Northern Long-Eared Bat

The availability of potential breeding or foraging habitat within the Project Area would change under Alternative 1. The quantity and quality of mid- to late-successional forest habitats would likely increase within the Project Area due to fire suppression and natural succession. Over time, large blocks of maturing habitat may be spatially distributed across the Project Area. The northern long-eared bat may experience an increase in available breeding habitat within such blocks as tree diameters and snags increase, the proportion of hardwoods increases, and canopy gaps that could

increase solar exposure of roosting trees develop. However, if natural succession leads to the loss of interspersed forest openings, wooded corridors, or forested wetlands, or if forested stands develop dense understory vegetation, the availability of foraging and/or travel corridors for northern long-eared bat may decline within the Project Area. Alternative 1 also would fail to control Scots pine and other NNIP. NNIP may replace native plants that provide food and cover for terrestrial and aquatic insects, reducing potential foraging habitat and the prey base for the northern long-eared bat.

Approximate range of northern long-eared bat (USDI 2013)
Figure 3-7



Alternative 1 would maintain current road and trail densities and existing human access and use throughout foraging and roosting habitat. As a result, the availability of potential breeding habitat may change from human activities such as cutting down potential roost trees for firewood. Disturbance also may lead to roost abandonment, or disrupt northern long-eared bats searching for roost or foraging sites. Human activities also may damage vegetation and increase the amount of bare ground within forest openings and wooded corridors, and/or reduce water quality in forested wetlands via soil erosion or sediment delivery. Degradation of forest openings, wooded corridors, and/or forested wetlands may lead to a reduction in available prey within potential foraging habitat. An increase in the number of users may also increase the risk of vehicle collisions and/or wildfires. However, human disturbance and associated reductions in breeding or foraging habitat would likely affect small acreages in localized areas within the Project Area in any given time period, allowing breeding and foraging potential in those areas that are undisturbed. Northern long-eared bats also may benefit from forest trails and roads because they minimize understory vegetation and provide more efficient travel corridors. Overall, Alternative 1 is expected to have

primarily beneficial effects on the roosting and foraging habitat for the northern long-eared bat, and any adverse indirect and direct effects on the bat are expected to be minimal given the large forest landscape within the range of the species on the HMNF that has breeding and foraging potential.

The Cumulative Effects of Implementing Alternative 1

Northern Long-Eared Bat

Human populations and associated land development, road construction, and recreational use are expected to increase on private lands within the MNF. In addition, a change in land use from larger forested parcels to smaller parcels with more residential and commercial development is occurring on private ownerships and is expected to continue into the foreseeable future. These activities have the potential to reduce total forest cover, increase forest fragmentation, and increase human access to areas that are likely utilized by the northern long-eared bat. Such activities that occur on non-NFS lands could result in a permanent loss of northern long-eared bat foraging and breeding habitat; remove, damage, or cause the abandonment of roost trees; reduce the quality and quantity of prey species; increase the risk of vehicle collisions and wildfires; and/or kill individual bats, especially non-volant pups, within the MNF.

Timber harvesting, fire suppression, savanna and prairie creation activities, fuel hazard reduction treatments, and the application of pesticides on NFS lands and private lands within the MNF may adversely affect the northern long-eared bat in the future. There may also be a loss of hardwood diversity via forest maturation, or pest species infestation, such as emerald ash borer, which may lead to a reduction in preferred roost tree species including ash and maple. In addition, mineral developments are reasonably certain to occur in the foreseeable future within the MNF and have the potential to cumulatively affect the northern long-eared bat.

Other management directives delineated in the Forest Plan promote mid- to late-successional forest types. Protected areas, including Special Areas, Wild and Scenic River designations, rare plant areas, and candidate RNAs would preserve hardwood forests, reducing habitat fragmentation. The old growth designation would provide planned old growth in the northern hardwood and long-rotation oak type forests. Management of forest types would continue to provide a stable or increasing amount of mature habitat as the acreage of pine thinnings, mature oak and aspen regeneration cuts, and dead tree salvage treatments is projected to remain at 1979-2005 levels. In addition, forestry management practices emphasize retaining dominate species in a stand and large snags, while increasing vertical and horizontal forest structure considered important for all forest dependent priority species. Overall, Forest Plan management directives would provide large blocks of maturing habitat, spatially interspersed with early successional vegetation types across the MNF. In the long term, the amount of suitable roosting and foraging habitat for the northern long-eared bat is expected to remain stable at a broad scale across the MNF.

The Direct and Indirect Effects of Implementing Alternative 2

Northern Long-Eared Bat

In the summer months, northern long-eared bats use forests within the MNF for roosting and breeding habitat. Proposed activities that may directly affect the northern long-eared bat are

vegetation management (commercial thinning, overstory removal, opening creation, opening restoration/maintenance, savanna restoration, broadcast/prescribed burning), aquatic habitat improvement (road/stream crossing improvements, in-stream structures) and transportation management (habitat protection, activities to repair resource damage, road closures, road construction and reconstruction). These actions would cause an unusual volume of human and ground disturbance if conducted during summer roosting and may kill or displace northern long-eared bats within the Project Area. Heavy equipment use, traffic associated with management activities, smoke and scorching during burns may cause bats to vacate roost trees and abandon pups. Destroying active roost trees during management activities may injure or kill adult bats and non-volant young. Conducting broadcast/prescribed burning during summer occupancy may result in direct mortality or injury to bats by burning, heat exposure, or smoke inhalation; bats also may be exposed to elevated concentrations of potentially harmful compounds within the smoke (e.g. carbon monoxide and irritants). The risk of direct mortality and injury to adult bats from broadcast/prescribed burning is expected to be low as long as fire intensity and crown scorch height are low. While adult bats may be able to move out of treated areas, non-volant pups are immobile and likely to be crushed by mechanical equipment or killed during broadcast/prescribed burns. Traffic associated with implementation also may temporarily increase the risk of mortality due to vehicle collisions; however, this risk is expected to be discountable given most activity would occur during the day when bats are inactive. In addition, disturbance from management activities may temporarily alter the movement or disrupt the normal behavior of northern long-eared bats searching for roosting and foraging sites, potentially reducing productivity.

Management activities conducted outside the summer roosting period would largely protect northern long-eared bats from potential direct affects. Except for broadcast/prescribed burning and road construction/reconstruction, all management activities would be prohibited between May1 and August 31 (see Appendix A). Implementation of other conservation measures described in Appendix A for the northern long-eared bat would further minimize the potential for adverse direct effects. For example, these measures would promote the retention of key habitat features such as retaining snags, den trees, and trees that have cavities, crevices, and/or sloughing bark.

Due to the Project Area occurring within the species range, Alternative 2 may change the availability of breeding or foraging habitat within the Project Area. Maternity roost trees have not been surveyed or identified within the Project Area. Alternative 2 proposes 1,412 acres of pine thinning, 45 acres of conifer overstory removal, conversion of 932 acres of mature forests to openland habitats (e.g. openings, savannas, prairies), and a total of 8.6 miles of road construction and reconstruction. These activities may result in the loss of active roost complexes or may remove trees that could provide potential roost complexes, which may result in a long term adverse effect to the northern long-eared bat. Loss of roost trees during summer occupancy may occur due to the window of time allowed for transportation management. If maternity roost trees are identified during subsequent surveys, they would be marked and activities would be performed carefully to avoid damaging them.

Activities proposed under Alternative 2 would likely have indirect effects on northern long-eared bat through habitat change. Vegetation and transportation management activities may kill and/or temporarily reduce habitat quality for insects that are eaten by northern long-eared bats within the Project Area. Heavy equipment use associated with proposed treatments may damage herbaceous vegetation and increase bare ground, and/or temporarily increase soil erosion and sediment delivery into streams and other aquatic habitats. Such activities may temporarily reduce habitat quality and quantity for terrestrial and aquatic insects, and subsequently populations, reducing

food resources for the northern long-eared bat. However, adverse effects to aquatic forage species would be minimized by implementing the conservation measures outlined in Appendix A, which would limit the potential for soil erosion and sediment delivery into streams, creeks, wetlands, and other waterbodies. On the other hand, given northern long-eared bats also forage within openlands, enhancement of openings and savannas/barrens may increase the availability of native plants that provide food and cover for terrestrial insects, subsequently increasing prey populations. Planting trees and shrubs along riparian corridors also may increase foraging opportunities. Overall, there would be no net change in prey availability for the northern long-eared bat.

In addition, implementation of proposed treatments may reduce understory vegetation within forested stands and increase the availability of wooded corridors that could be used for travel. This could facilitate movement of northern long-eared bats between patches of suitable habitat that remain within the Project Area. Broadcast/prescribed burning also may contribute to tree mortality, increasing the number of snags and producing cavities within those snags, which could provide potential roost trees.

Under Alternative 2, strip/patch or spot application of glyphosate, triclopyr, or imazapic would be used to control NNIP and persistent woody vegetation. As stated above, under *Direct and Indirect Effects* for KBB, glyphosate, triclopyr, and imazapic pose little or no risk to wildlife at rates commonly used by the Forest Service, as long as the herbicides are used in accordance with the manufacturer label. The Round-Up formulation of glyphosate and butoxyethyl ester formulations of triclopyr are exceptions to this generalization due to extremely low LC_{50} values for aquatic species. However, only formulations labeled for use in aquatic areas for glyphosate and triclopyr would be used within 100 feet of wet areas, such as lakes, wetlands, and riparian corridors. Northern long-eared bats and their prey species may be exposed to herbicide by direct contact with herbicide spray or recently treated foliage, and/or by drinking from water sources that have been contaminated by surface runoff. Prey species of northern long-eared bats also may be exposed by ingesting treated foliage. Risk assessments for glyphosate and triclopyr conclude that small birds and animals that consume vegetation or insects from areas treated with the maximum application rate for an extended period of time could experience adverse effects. However, this type of treatment would not occur. In addition, glyphosate, triclopyr, and imazapic are not expected to bioaccumulate in the food chain. Because strip/patch or spot application of herbicide would be used to treat small areas, northern long-eared bats and their prey species would not be likely to come into direct contact with herbicide spray or recently treated foliage. Moreover, herbicide treatments would be performed during daylight hours when most bats are roosting, further reducing potential exposure to herbicides. Thus, chemical removal of NNIP is not expected to adversely affect the northern long-eared bat, its potential foraging habitat, or its prey base. Long-term impacts from mechanical and chemical removal of invasive species would likely benefit northern long-eared bats by increasing native plant species diversity and abundance in treated areas, resulting in slightly improved prey habitat.

Under Alternative 2, habitat protection measures, activities to repair resource damage (i.e. site rehabilitation via removal of NNIP and trash, and seeding/planting activities), and transportation management activities (i.e. road closures, road construction, road reconstruction) would be implemented to mitigate and reduce environmental impacts from human use within the Project Area. These treatments are expected to have primarily beneficial direct and indirect effects to local populations of the northern long-eared bat within the Project Area, and any adverse direct and indirect effects would be expected to be minimal with implementation of the conservation measures outlined in Appendix A. Reducing the amount of unclassified roads, closing NFS roads,

and blocking vehicular access to managed openlands may decrease levels of disturbance and reduce the risk of motorized users and other recreational impacts, as described above under the No Action Alternative.

Road closures and treatments to rehabilitate and protect openings, savannas, barrens, prairies, and grasslands with resource damage would likely increase the diversity and abundance of native forbs, grasses, and shrubs, and subsequently prey species for the northern long-eared bat within openlands and along right-of-ways. Over time, the effects of fragmentation and erosion/sediment delivery would be reduced as native vegetation became re-established along closed roads.

Over time, habitat protection, resource damage, and transportation management activities proposed under Alternative 2 would likely decrease the risk of mortality and improve habitat quantity and quality for the northern long-eared bat within the Project Area. Alternative 2 would provide more protection from human access and use than Alternative 3 given that it proposes an additional 1.1 miles of NFS road closures.

Overall, management activities proposed under Alternative 2 may have beneficial and negative indirect and direct effects to northern long-eared bats and their roosting and foraging habitats within the Project Area. Adverse effects would be expected to be minimal with the implementation of the conservation measures listed in Appendix A.

The Cumulative Effects of Implementing Alternative 2

Northern Long-Eared Bat

The cumulative effects of activities on non-Federal lands on the northern long-eared bat would be the same as those described under the No Action Alternative. Overall, the effects of the proposed management activities on Federal lands under Alternative 2 are expected to be local, may impact only a small portion of the population, and are not likely to have adverse cumulative effects on the northern long-eared bat. With the implementation of the conservation measures outlined in the *Northern Long-Eared Bat Interim Conference and Planning Guidance*, and utilizing best available science as it becomes available, the amount of suitable habitat for the northern long-eared bat is expected to remain stable at a broad scale across the MNF.

The Direct and Indirect Effects of Implementing Alternative 3

Northern Long-Eared Bat

Management activities proposed under Alternative 3 are nearly identical to those proposed under Alternative 2. However, there would be a reduced amount of opening restoration, opening creation, and savanna restoration activities (i.e. 932 acres under Alternative 2 versus 730 acres under Alternative 3) and fewer acres would be broadcast burned (i.e. 746 acres under Alternative 2 versus 696 under Alternative 3). Therefore, the anticipated direct and indirect effects on northern long-eared bat within the Project Area would be similar, but slightly less than those under Alternative 2.

The Cumulative Effects of Implementing Alternative 3

Northern Long-Eared Bat

Cumulative effects under Alternative 3 would be indistinguishable from those described under Alternative 2.

Effects on Regional Forester's Sensitive Species and Other Wildlife

Wildlife Associated with Early Successional Vegetative Types

The Direct and Indirect Effects of Implementing Alternative 1

Under Alternative 1, the quantity and quality of early successional vegetative types would continue to decline in the Project Area due to fire suppression and natural succession. As remnant openings, savannas, barrens, grasslands, and prairies fill in with fire-intolerant woody and shade-tolerant herbaceous species, suitable habitat for wildlife associated with early successional habitats such as the dusted skipper, Persius duskywing, frosted elfin, Ottoe skipper, hill-prairie spittlebug, prairie warbler, red-headed woodpecker, and eastern box turtle would likely become scarcer. Savanna plants such as little bluestem and wild lupine would be shaded-out or out-competed as the amount of sunlight reaching the understory vegetation becomes less. The extent of openings, savannas, barrens, grasslands, and prairies on NFS lands within the Project Area are small and isolated and most occurrences of RFSS dependent on these habitat types are documented on non-National Forests System lands; therefore, the future sustainability of these populations relies on the cooperative management efforts of the HMNF and its partners to increase the quantity and quality of openlands, as well as dispersal corridors, across landownerships in the Project Area. Without cooperative restoration efforts, reductions in habitat quality and quantity within corridors and openland habitats likely would subsequently lead to reductions in populations of RFSS and other early successional vegetation dependent species. In addition to the loss of openland habitats, early successional forest types (such as aspen) would continue to decline due to succession. As forest communities mature and become replaced by white pine, red pine, and white oak stands, acreage of suitable habitat for, and subsequently numbers of, ruffed grouse and whip-poor-will in the Project Area, would likely decline. Other wildlife species preferring openland habitats or early successional forest for parts of their life cycles may experience a reduction in habitat quantity and quality under this alternative including American woodcock, cottontail rabbit, snowshoe hare, fox and gray squirrel, red and gray fox, coyote, wild turkey, and white-tailed deer.

Alternative 1 would also fail to control NNIP within remnant openings, savannas, barrens, grasslands, and prairies within the Project Area. Twenty-three NNIP were found within areas proposed for treatment during botanical surveys. Failure to control invasive plants would not directly result in adverse impacts to local populations of wildlife. However, failure to successfully control these invasive species would allow the continued infestation and degradation of more areas of wildlife habitat within these early successional vegetative types. Aggressive invasive plants species such as leafy spurge tend to replace native plants upon which wildlife generally depend for food and cover. In general, species having relatively specific habitat requirements are more susceptible to adverse effects from the continued spread of invasive plants than habitat generalists. For example, habitat quantity and quality for frosted elfin would likely decline if autumn olive,

honeysuckle, and/or leafy spurge shaded-out or out-competed wild lupine and wild (or false) indigo (*Baptisia australis*) - its host plants - and other important nectar sources.

In addition, habitat quantity and quality for wildlife associated with early successional vegetative types may decline under Alternative 1 because it would maintain current road and trail densities, and thus human access and use, within the Project Area. Currently, roads, trails, and concentrated use are occurring in openings, savannas, barrens, and prairies within the Project Area. Numerous oil/gas pipeline and power line right-of-ways intersect roads and trails within the Project Area and are commonly used travel routes by ORVs. Some roads, trails, and right-of-ways within the Project Area contain concentrations of forbs, grasses, and "mud-puddling" locations that provide suitable habitat and/or dispersal corridors for species associated with early successional vegetative types. Resource damage from unapproved recreational activities, the primary one being ORV use, has been documented within many of the openlands and right-of-ways that occur within the Project Area, many of which have documented use by RFSS dependent on openland habitat types. In addition, horseback riding occurs on County and Forest System roads throughout the Project Area, and cross-country travel is permitted for horseback riding, except where posted signs exclude this form of recreation. Vehicle use, dispersed camping, horseback riding, and foot traffic along roads and trails and within adjacent open areas or right-of-ways has been analyzed under this alternative for KBB; effects to early successional species would be similar to those described in the KBB section.

As habitat quality and quantity decreases for wildlife associated with early successional vegetative types under Alternative 1, occurrences of these species within the Project Area would likely decline. Surviving populations would become even more isolated and disconnected, and thus subject to a higher risk of extirpation from catastrophic events. Overall, Alternative 1 is likely to have adverse direct and indirect effects on RFSS associated with early successional vegetative types.

The Cumulative Effects of Implementing Alternative 1

The cumulative effects of this alternative on wildlife associated with openland habitats would be the same as those described for KBB under Alternative 1.

In addition to not restoring and maintaining openland habitats as directed by the Forest Plan, this alternative would not follow Forest Plan guidance for the maintenance of early successional forest communities within the HMNF. Suitable habitat for ruffed grouse, whip-poor-will, and other wildlife species associated with early successional forests is expected to decline on non-Federal lands within the MNF. Private forest lands are expected to be further subdivided for residential and commercial development, reducing the amount of total forest cover and increasing forest fragmentation. Newly created non-forested areas on private lands within the MNF are unlikely to provide the diverse habitat mosaics preferred by wildlife associated with early successional forests. The creation of non-forested areas on private lands within the MNF also is reducing the acreage of early successional aspen stands. Private forested lands are expected to shift towards a mix of young and mature oak and lowland hardwoods, replacing other forested types including aspen. Overall, habitat quantity and quality for wildlife associated with early successional forests, and subsequent occurrences of these species, would likely decline on private lands within the MNF boundary. With the increasing development and fragmentation of private lands, managing for early successional vegetative types on Federal lands within the MNF is likely to become more important in the future. Because the HMNF would not manage for early successional forest types

under Alternative 1, these forest types would likely continue to decline on Federal lands due to succession. Therefore, this alternative would have adverse cumulative effects on wildlife associated with early successional forest communities.

The Direct and Indirect Effects of Implementing Alternative 2

Management activities proposed under Alternative 2 may have direct effects on wildlife associated with early successional vegetative types within the Project Area, similar to those described for KBB. Opening restoration/maintenance, opening creation, savanna restoration, commercial thinning, overstory removal, broadcast burning, maintenance of in-stream structures, riparian planting, and road/stream crossing improvements may kill, displace, or disrupt the normal behavior of small numbers of dusted skipper, Persius duskywing, frosted elfin, Ottoe skipper, hill-prairie spittlebug, prairie warbler, red-headed woodpecker, eastern box turtle, whip-poor-will, and ruffed grouse and other early successional vegetation associated species within the Project Area. Invertebrates and reptiles have limited mobility and would likely not escape proposed management activities. While eastern box turtles and some adult stages of invertebrates such as dusted skipper and frosted elfin may be able to move out of treated areas, the eggs and larvae of these species are immobile and thus are particularly vulnerable and likely to be crushed during mechanical treatments such as mowing or disking, being burned during prescribed fires, or trampled during hand cutting. In addition, the proposed treatments may affect the movement patterns and nests of the prairie warbler, red-headed woodpecker, whip-poor-will, and ruffed grouse. Ground disturbances within openings may also destroy eastern box turtle nests and kill unhatched or dispersing young, reducing reproductive success. Additionally, management activities may disrupt the normal behavior of wildlife, which could limit the use of foraging, nesting, roosting, or hibernation sites and potentially affect productivity. Vehicle use and foot traffic along roads and within openings during management activities may temporarily increase the level of disturbance; damage plant species used for food or cover; temporarily displace, alter movement, or disrupt normal behavior of wildlife; and increase the risk of vehicle collisions, and directly harming, harassing, or killing wildlife. In addition, amphibian populations within treated stands would likely decrease within two years of conducting timber harvests due to leaf and moisture loss. This would likely rebound to normal levels after 20 years (Ash 1997).

Breeding birds, small mammals, and less mobile species, such as reptiles and invertebrates, are most likely to be directly affected in these operations due to the use of heavy equipment and activities associated with prescribed burning. Operations during the breeding season would have the potential to cause disturbance, destroy or damage nests and dens, or kill/injure small young and less mobile species. Management activities conducted between September and March could directly impact wildlife use in the fall and small numbers of wintering animals, but would largely protect nesting birds, hibernating reptiles, and other breeding wildlife. For example, because the eastern box turtle occupies hibernacula underground during the winter, management activities are more likely to have a direct effect on the eastern box turtle between early spring and late fall when they are most active (Hyde 1999). The season, intensity, and frequency of management activities, particularly prescribed burns, also could have detrimental effects on dusted skipper, frosted elfin, hill-prairie spittlebug, and other invertebrates dependent on openland habitats through the killing of eggs, larvae, or adults. Prescribed burns may kill all life stages of invertebrates within areas proposed for opening restoration/maintenance, opening creation, and savanna restoration given burns often need to be conducted during the growing season in order to meet vegetative objectives. Operations during the larval and flight periods have the greatest potential of causing disturbance, damaging host plants, and killing or disrupting the behavior of invertebrates.

Opening restoration/maintenance, opening creation, savanna restoration, broadcast burning, commercial thinning, and overstory removal would involve applying a series of treatments over the next decade to meet vegetative management objectives. Each of these treatments has the potential to have direct effects on wildlife during each entry. As stands become more open and trees/shrubs regenerate, the potential for wildlife associated with early successional habitats to enter treated units would increase. In addition, timber harvests during savanna restoration, opening creation, commercial thinning, or overstory removal adjacent to openlands with documented occurrences of early successional wildlife species also could have direct effects by creating ecological traps. As treated openings, savannas, barrens, and dry sand prairies progress towards meeting objectives for vegetative cover and composition, wildlife dependent on openland habitats are likely to colonize managed areas increasing the potential for direct effects on dispersing individuals and newly occupied areas during future entries.

Implementation of the conservation measures listed for KBB in Appendix A within stands occupied by KBB, or adjacent to or within dispersal distance of KBB sites, would minimize the potential for adverse direct effects on invertebrates, nesting birds, and mating reptiles associated with early successional habitats. For example, except for prescribed burning and broadcast burning, management activities proposed within occupied KBB sites would be prohibited between March 15 and August 15, while those proposed adjacent to or within dispersal distance of KBB sites would be prohibited during the KBB flight period (typically between May 10 and August 15, depending on the weather). To reduce the potential of creating ecological traps, a minimum forested buffer of 50 meters would be maintained around KBB sites located adjacent to timber harvests. In addition, only a portion of openings, savannas, and barrens with a history of use by KBB would be treated each season, which would reduce direct effects on RFSS invertebrates and facilitate re-colonization of recently treated portions. Potential adverse effects would be reduced further with the implementation of the conservation measures listed for RFSS associated with early successional vegetative types in Appendix A within stands where they are documented or found (Table B3 in Appendix B). For example, management activities would be restricted to certain time periods to avoid impacting migrating and nesting RFSS birds and reptiles. The boundaries of openings occupied by rare invertebrate species would be delineated and management activities would follow specified treatment timing, intensity, and rotation schedules. In addition, the locations of known nests, roosts, or burrows of RFSS would be flagged or marked, and management activities would be performed carefully to avoid physical injury to nests or burrows and less mobile RFSS. If other sensitive wildlife species associated with early successional vegetative types are found during project activities, appropriate protection measures would be implemented to reduce potential adverse effects.

Under Alternative 2, strip/patch or spot application of glyphosate, triclopyr, or imazapic is proposed to control NNIP and persistent woody vegetation. As stated above under Direct and Indirect Effects for KBB, glyphosate, triclopyr, and imazapic pose little or no risk to wildlife at rates commonly used by the Forest Service, as long as the herbicides are used in accordance with the manufacturer label, and formulations labeled for use in aquatic areas for glyphosate and triclopyr are used within 100 feet of wet areas such as lakes, wetlands, and riparian corridors (USDA 2004b; USDA 2011c; USDA 2011d). Wildlife associated with early successional vegetative types could be exposed to herbicides by direct contact with herbicide spray or with recently treated foliage. Oral exposure also could occur by ingesting contaminated nectar or by drinking from water sources that have received contaminated surface runoff. However, because strip/patch or spot application of herbicide would be used to treat small areas, wildlife associated with early successional vegetative types would not be likely to come into direct contact with

herbicide spray or recently treated foliage, and nectivores, insectivores, and fruitivores such as dusted skipper, hill-prairie spittlebug, and eastern box turtle are not likely to feed solely on plant parts recently treated with herbicide sprays. The risk assessments for glyphosate and triclopyr conclude that small birds and animals that consume vegetation or insects from areas treated with the maximum application rate for an extended period of time could experience adverse effects. However, this type of treatment would not occur. In addition, glyphosate, triclopyr, and imazapic are not expected to bioaccumulate in the food chain. If work is conducted in areas containing RFSS, locations of nests, concentrations of host plants, and other immobile wildlife features would be prominently marked whenever possible and operators would be trained to visually recognize the protected features. The potential for adverse effects to RFSS dependent on early successional habitats would be reduced further within stands occupied by KBB, or adjacent to or within dispersal of KBB sites by implementing timing restrictions and avoiding wild lupine during herbicide application as outlined in the conservation measures listed for KBB in Appendix A.

Vegetative management proposed under Alternative 2 would likely have indirect effects on local populations of dusted skipper, Persius duskywing, frosted elfin, Ottoe skipper, hill-prairie spittlebug, prairie warbler, red-headed woodpecker, eastern box turtle, whip-poor-will, and ruffed grouse through habitat change. For example, red-headed woodpeckers and other wildlife species dependent on hard mast production (e.g. wild turkey, squirrels, and white-tailed deer) would likely experience a slight reduction in food resources due to savanna restoration treatments. Management activities also may damage vegetation and increase the amount of bare ground within treated openings, temporarily decreasing cover and the abundance of native grasses, herbs, wildflowers, and fruit-bearing shrubs that serve as food for openland-dependent species. Specifically, lower densities of wild lupine and other host plants used by RFSS invertebrates may lead to temporary reductions in reproductive successive. In addition, without sufficient knowledge of what plant species are present on a given site and their response to different management activities, implementation of proposed treatments may increase undesired plant species. For example, fire may either increase the abundance of NNIP, such as spotted knapweed, and/or native species, such as Pennsylvania sedge, that may out-compete wild lupine and nectar plants. Hardwood saplings that regenerate following manual or mechanical woody vegetation removal treatments also may shade-out more desirable native savanna plant species. Disturbance from restoration activities also may create conditions favorable for establishment of NNIP, such as spotted knapweed and common St. John’s-wort. Proposed herbicide treatments would minimize occurrence of non-natives and favor more desirable native nectar species. Effects of herbicides on the growth and flowering of wild lupine and other nectar plant species varies, and at times may result in a temporary reduction in habitat quantity and quality for invertebrates and other nectivores and herbivores. Such reductions are expected to be minimal with the seeding/planting of wild lupine and other native nectar plants. Controlling non-native invasive shrubs (e.g. autumn olive and honeysuckle) that bear fruit and serve as nectar sources for bees and other insects would likely reduce available habitat and food for wildlife associated with early successional vegetative types such as dusted skipper and eastern box turtle. Overall, potential adverse indirect effects to wildlife associated with early successional vegetative types are expected to be minimized with the implementation of the conservation measures listed for KBB in Appendix A within stands occupied by KBB, or adjacent to or within dispersal distance of KBB sites, and the conservation measures listed for RFSS in Appendix A within stands where they are documented or found.

Under Alternative 2, opening restoration/maintenance, opening creation, and savanna restoration also may improve habitat for herbivores occurring within the Project Area. In particular, deer may experience an increase in habitat quantity and quality, potentially causing localized increases in

deer numbers and increased herbivory on wild lupine and other nectar plants within opening restoration/maintenance, opening creation, and savanna restoration areas. Herbivory on wild lupine and other nectar plants may destroy eggs and larvae of RFSS invertebrates such as frosted elfin, and reduce productivity in the long-term by limiting the growth of native nectar species. Such effects have been noted for KBB. High deer densities have been reported to kill KBB, reduce lupine populations, and potentially reduce KBB reproduction by limiting lupine growth. Although Schweitzer (1994) recommends managing deer populations to levels where no more than 15% of lupine flowers are consumed, management of deer populations is outside Forest Service jurisdiction and authority.

Much of the habitat change expected under the Proposed Action would likely have beneficial indirect effects to dusted skipper, Persius duskywing, frosted elfin, Ottoe skipper, hill-prairie spittlebug, prairie warbler, red-headed woodpecker, eastern box turtle, whip-poor-will, and ruffed grouse. Proposed vegetative management activities would increase the quantity and quality of openings, savannas, barrens, grasslands, and prairies and early successional forest types. Overstory removal of red pine would increase age-class and species diversity of trees and shrubs within treated stands, enhancing habitat for wildlife that utilize early successional forest types such as whip-poor-will and ruffed grouse. Commercial thinning of red pine also would increase species and structural diversity of trees and shrubs in the understories of treated stands. Overstory removal of red pine would promote oak regeneration with variable understories of oaks, pines, and shrubs on 45 acres, while commercial thinning of red pine would regenerate oaks, maple, jack pine, and shrubs in the understories of treated stands on 1,412 acres under Alternative 2. Opening restoration/maintenance, opening creation, and savanna restoration activities would create or enhance openings, savannas, barrens, and dry sand prairies on up to 932 acres under Alternative 2. This acreage would contribute to the Forest Plan's management goals for restoring savannas/barrens and upland openings. Opening restoration/maintenance, opening creation, and savanna restoration activities would increase habitat quantity and quality for wildlife associated with early successional vegetative types by: maintaining open areas; providing a diversity of foraging habitats; promoting nectaring sources from shrubs and wildflowers, larval host plants including wild lupine, and savanna plant species such as warm season grasses including bluestem; and providing other features important to wildlife, such as sunning areas, roosting sites, and nesting areas.

As openland habitats with little bluestem, wild lupine, flowering spurge, wild indigo, false indigo, wild strawberry, and other nectar plants and warm season grasses increase, suitable habitat for, and subsequently occurrences of, invertebrates such as dusted skipper, Persius duskywing, Ottoe skipper, hill-prairie spittlebug, Sprague's pygarctia, and frosted elfin would likely increase. The red-headed woodpecker, eastern box turtle, and whip-poor-will have diverse habitat requirements that include openland habitats, and consequently would also benefit from opening restoration/maintenance, opening creation, and savanna restoration activities. Red-headed woodpeckers require open woodlands with mast crop abundance and nesting cavities in live trees, dead stubs, snags, utility poles, or fence posts (USDA 2005b; NatureServe 2014). Eastern box turtles occur in upland forested habitats with sandy soils, thickets, old fields, pastures, marshes, vegetated dunes, and bog edges near or adjacent to a source of water, and require access to nearby sandy, open areas for nesting (Hyde 1999; USDA 2005b; NatureServe 2014). Whip-poor-wills occur in open coniferous, deciduous, and mixed woodlands with well-spaced trees and a low canopy, abundant shade, nearby open areas, and sparse ground cover (USDA 2005b; NatureServe 2014). Because opening restoration/maintenance, opening creation, and savanna restoration activities directed towards providing suitable KBB habitat would create a heterogeneous habitat

mosaic that provides sub-habitat variation in tree canopy and shrub cover, plant community composition, thermal environment, topography, and soil moisture, these treatments would provide the range of habitat conditions required by red-headed woodpecker, eastern box turtle, and whip-poor-will. Other wildlife species that may experience an increase in habitat quantity and quality, and subsequently population numbers, following treatments to enhance early successional vegetative types within the Project Area include, but are not limited to: American woodcock, cottontail rabbit, snowshoe hare, fox and gray squirrel, red and gray fox, coyote, wild turkey, and white-tailed deer. Increases in occurrences of species dependent on early successional vegetative types (e.g. of red-headed woodpecker, Hill's thistle, olive-sided flycatcher, eastern box turtle, Ottoe skipper, American woodcock, ruffed grouse, whip-poor-will, Blanding's turtle, hill-prairie spittlebug) have been documented following opening and savanna restoration efforts on other parts of the HMNF (USDA 2013d).

Overall, vegetative management activities proposed under Alternative 2 are expected to have primarily beneficial direct and indirect effects on wildlife associated with early successional vegetative types within the Project Area, and any adverse direct and indirect effects are expected to be minimal with the implementation of the conservation measures listed in Appendix A. Given fewer acres of opening restoration/maintenance, opening creation, and savanna restoration are proposed under Alternative 3 than Alternative 2, Alternative 2 is expected to have more beneficial indirect effects to wildlife associated with early successional vegetative types. Not only would Alternative 2 result in a larger increase in habitat quantity and quality for species dependent on openlands, but it would also provide more opportunities to increase connectivity of openings, savannas, barrens, grasslands, and dry sand prairies across different land ownerships by facilitating cooperative management activities with adjacent landowners.

ORV use, cross-country travel via foot or horseback, and dispersed camping may increase within areas proposed for opening restoration/maintenance, opening creation, and savanna restoration. Increased recreational use may reduce the quantity and quality of early successional habitat as described above under KBB.

The potential for adverse effects from human use on early successional wildlife species would be minimized by installing signs within or adjacent to opening creation, opening restoration/maintenance, and savanna restoration treatment areas explaining the benefits of restoring native plant communities and requesting visitors to stay on roads and trails. If damage from human activities is noted within managed openlands, additional steps may be taken to limit the potential for resource damage, including, but not limited to, temporary closure orders and the installation of physical barriers (e.g. barrier posts, gates, or piling brush around the perimeter of treatment areas).

In addition to such habitat protection measures, activities to repair resource damage (i.e. site rehabilitation via removal of NNIP and trash, and seeding/planting activities), and transportation management activities (i.e. road closures, road construction, road reconstruction) would be implemented to mitigate and reduce environmental impacts from human use within the Project Area. These treatments are expected to have primarily beneficial direct and indirect effects to local populations of wildlife associated with early successional vegetative types within the Project Area, and any adverse direct and indirect effects would be expected to be minimal with implementation of the conservation measures outlined in Appendix A. Reducing the amount of unclassified roads, closing Forest System roads, and restricting vehicle access to managed

openlands may reduce the risk of motorized users in these habitats, as described above under KBB.

Treatments to rehabilitate and protect openings, savannas, barrens, and dry sand prairies that have resource damage would increase the diversity and abundance of native forbs and grasses. Closure of roads within or adjacent to areas proposed for opening restoration/maintenance, opening creation, and savanna restoration treatments also would likely experience an increase in nectar plant availability, providing food resources and improving the quality and quantity of dispersal corridors for wildlife associated with openlands such as dusted skipper, eastern box turtle, and frosted elfin. Human use and its associated impacts on wildlife associated with early successional vegetative types where County roads and Forest System roads remain open to motorized use would be similar to those described under the KBB section under the No Action Alternative. Potential adverse effects to wildlife resulting from continued use of roads by motorized vehicles and horses, as well as cross-country travel, would be minimized by installing signs and physical barriers within managed openings, savannas, barrens, grasslands, and prairies, and/or implementing temporary closure orders where resource damage is noted (see Appendix A).

Overall, habitat protection, resource damage, and transportation management activities, proposed under Alternative 2, would likely decrease the risk of mortality and improve habitat quantity and quality for dusted skipper, Persius duskywing, frosted elfin, Ottoe skipper, hill-prairie spittlebug, prairie warbler, red-headed woodpecker, eastern box turtle, whip-poor-will, and ruffed grouse and other wildlife associated with early successional vegetative types within the Project Area. Although both alternatives propose the same habitat protection and resource damage management activities, Alternative 2 would include an additional 1.1 miles of Forest Service road closures. As such, Alternative 2 would provide more protection from human access and use than Alternative 3.

The Cumulative Effects of Implementing Alternative 2

The cumulative effects of activities on non-Federal lands on wildlife species associated with early successional vegetative types would be the same as those described under the No Action Alternative. Because habitat quantity and quality for early successional wildlife species is expected to decline on private lands within the MNF boundary, managing for openlands and early successional forest communities on Federal lands is likely to become more important in the future.

Opening restoration/maintenance, opening creation, and savanna restoration activities would create or enhance openings, savannas, barrens, and dry sand prairies on up to 932 acres under Alternative 2. The proposed opening restoration/maintenance, opening creation, and savanna restoration activities would help achieve the goals outlined in the Forest Plan for the restoration and maintenance of upland openings, savannas, barrens, and dry sand prairies within the HMNF. Given land ownership is highly fragmented within the Project Area, conducting cooperative management activities with adjacent landowners is critical to maximize increases in the acreage, distribution, and connectivity of high quality openlands across landscapes and jurisdictional boundaries. Over the last two decades, non-profit organizations, local and state government agencies, and private landowners have been actively managing over 750 acres to restore oak-pine savannas for the KBB and other plants and animals dependent on this rare ecosystem. The HMNF would work in cooperation with these partners to conduct coordinated management activities, particularly prescribed burning under Alternatives 2 and 3. However, Alternative 2 would cultivate more opportunities to work with adjacent landowners since it would include treating an additional 156 acres of NFS lands that are adjacent to several large KBB restoration areas being

managed by other landowners. Implementation of the conservation measures noted in Appendix A would minimize potential adverse effects to RFSS and other wildlife species dependent on early successional habitats on NFS lands within the Project Area. Although increases in human populations and associated land uses and developments are expected within the MNF in the future, the positive effects of Forest Service projects such as the Proposed Action should help to mitigate potential negative effects of activities on private lands.

Over the next 50 years, stands proposed for treatment under Alternative 2 would regenerate and mature, again favoring wildlife species that prefer mature forest types. However, based upon management direction in the Forest Plan, reversion to pre-treatment conditions would likely be prevented as vegetation management would continue to occur within the MNF in the future. Overall, the net long-term cumulative effect of the Proposed Action and other protective measures and planned activities within the MNF would be beneficial to wildlife associated with early successional vegetative types.

The Direct and Indirect Effects of Implementing Alternative 3

Management activities proposed under Alternative 3 would have similar, but slightly reduced, direct and indirect effects on wildlife associated with early successional vegetative types within the Project Area as described for Alternative 2, with the following exceptions. Commercial thinning of red pine would regenerate oaks, maple, jack pine, and shrubs in the understories of treated stands on 1,412 acres under Alternative 2, whereas commercial thinning would occur on 1,457 under Alternative 3. Opening restoration/maintenance, opening creation, and savanna restoration activities would create or enhance openings, savannas, barrens, and dry sand prairies on up to 932 acres under Alternative 2, but only 730 acres under Alternative 3. Both acreages would contribute to the Forest Plan's management goals for restoring savannas/barrens and upland openings. Overall, vegetative management activities proposed under Alternatives 2 and 3 are expected to have primarily beneficial direct and indirect effects on wildlife associated with early successional vegetative types within the Project Area, and any adverse direct and indirect effects are expected to be minimal with the implementation of the conservation measures listed in Appendix A. Given fewer acres of opening restoration/maintenance, opening creation, and savanna restoration are proposed under Alternative 3 than Alternative 2, Alternative 2 is expected to have more beneficial indirect effects to wildlife associated with early successional vegetative types. Not only would Alternative 2 result in a larger increase in habitat quantity and quality for species dependent on openlands, but it would also provide more opportunities to increase connectivity of openings, savannas, barrens, grasslands, and dry sand prairies across different land ownerships by facilitating cooperative management activities with adjacent landowners.

Although Alternatives 2 and 3 propose the same habitat protection and resource damage management activities, Alternative 2 would include an additional 1.1 miles of Forest Service road closures. As such, Alternative 2 would provide more protection from human access and use than Alternative 3.

The Cumulative Effects of Implementing Alternative 3

The cumulative effects of Alternative 3 would essentially be the same as those described under Alternative 2, with the following exception. Alternative 3 would cultivate fewer opportunities to conduct cooperative savanna restoration activities since it excludes treating an additional 156 acres

of Federal lands that are adjacent to several large KBB restoration areas being managed by other landowners.

Wildlife Associated with Mid- to Late-Successional Forest Types

The Direct and Indirect Effects of Implementing Alternative 1

Under Alternative 1, the quantity and quality of mid- to late-successional forest habitats would continue to increase in the Project Area due to fire suppression and natural succession. Over time, Alternative 1 would create large blocks of maturing habitat spatially distributed across the Project Area. The quality of forested stands within such blocks may increase for northern goshawk, red-shouldered hawk, bald eagle, Louisiana waterthrush, eastern box turtle, black bear, and other wildlife species associated with mid- to late-successional forest types (e.g. pileated woodpecker, brilliant scarlet tanager, red and gray fox, coyote, black-throated green warbler, gray and fox squirrel, white-tailed deer, bobcat, and northern flying squirrel). Tree diameters, understory growth, the proportion of hardwoods, large woody debris, snags, and tree cavities would all increase, and canopy gaps would develop. As these mature forest characteristics develop, northern goshawks, red-shouldered hawks, bald eagles, and Louisiana waterthrushes would likely experience an increase in suitable nesting and foraging habitat.

In particular, an increase in mature forest near rivers, streams, lakes, ponds, swamps, and wetlands may increase the availability of nesting, roosting, and perching sites for bald eagles, red-shouldered hawks, and Louisiana waterthrush. Increases in mature forest with canopy gaps near a source of water also may increase foraging and nesting habitat for eastern box turtles. In addition, greater understory growth and woody debris may increase the abundance and availability of potential denning sites for black bears and prey species for black bears, northern goshawks, and red-shouldered hawks. However, if succession leads to the loss of interspersed forest openings, uplands, and/or wetlands, the availability of suitable nesting and/or foraging habitat for wildlife associated with mid- to late-successional forest types may decline. For example, the loss of intermittent openings may reduce the availability of unshaded nesting sites adjacent to upland forests, which are critical for successful eastern box turtle reproduction (Hyde 1999).

Alternative 1 would also fail to control Scots pine and other NNIP such as leafy spurge and spotted knapweed that may out-compete native woody and herbaceous plants in the Project Area, reducing the quantity and quality of breeding and foraging habitat for wildlife species associated with mid- to late-successional forest habitats. Scots pine may replace native forest species, including hardwoods, reducing the quantity and quality of suitable nesting habitat for mid- to late-successional avian species. In addition, NNIP may replace the native plants that provide food and cover for small mammals, birds, and terrestrial and aquatic insects. This would reduce the suitable foraging habitat and prey base for wildlife species associated with this habitat type. Reductions in native plants (such as berry producing species) and invertebrates resulting from the spread of invasive species may also reduce suitable foraging habitat and prey base for the eastern box turtle and the black bear. However, this potential adverse effect would likely be minimal due to the small acreages affected.

Habitat quantity and quality for wildlife associated with mid- to late-successional forest types may decline under Alternative 1 because it would maintain current road and trail densities, and thus human access and use, within the Project Area. Numerous oil/gas pipeline and power line right-of-ways intersect roads and trails within the Project Area, and are commonly used travel routes by

ORVs. Resource damage from unapproved recreational activities, the primary one being ORV use, has been documented on NFS lands within the Project Area, as previously described. Vehicle use, dispersed camping, horseback riding, and foot traffic causes disturbance of wildlife, increased risk of nest trees being cut down for firewood, risks of ground nests of eastern box turtles being destroyed, vehicle collisions with wildlife, and increased potential of wildfires. Such disturbance may cause northern goshawks, red-shouldered hawks, bald eagles, Louisiana waterthrushes, and other birds associated with forested habitats to abandon their nest sites, and disrupt the normal nesting and foraging behavior of wildlife associated with mid- to late-successional forest types, limiting use of nest sites and foraging areas and potentially affecting productivity.

These activities may also damage vegetation and increase the amount of bare ground within forest openings and upland areas, and/or reduce water quality in rivers, streams, lakes, ponds, swamps, and wetlands via soil erosion or sediment delivery. Degradation of forest openings, uplands, and aquatic habitats may lead to a reduction in available foraging and/or nesting habitat for wildlife associated with mid- to late-successional forest types. However, human disturbance and associated reductions in nesting or foraging habitat would likely affect small acreages in localized areas within the Project Area in any given time period, allowing nesting and foraging potential in those areas that are undisturbed. Overall, Alternative 1 is expected to have primarily beneficial direct and indirect effects on wildlife associated with mid- to late-successional forest habitats, and any adverse direct and indirect effects are expected to be minimal.

The Cumulative Effects of Implementing Alternative 1

Increases in human populations and associated land development, road construction, and recreational uses are expected on private lands within the HMNF. In addition, a change in land use from larger forested parcels to smaller parcels with more residential and commercial development is occurring on private ownerships and is expected to continue into the foreseeable future. These activities would likely reduce the amount of total forest cover, increase forest fragmentation, and increase the potential for human access and use near northern goshawk, red-shouldered hawk, bald eagle, Louisiana waterthrush, eastern box turtle, and black bear nesting, roosting, perching, foraging, and denning sites. Subsequently, this may lead to increased levels of disturbance (e.g. human activity, noise, and habitat degradation), effects from habitat fragmentation (e.g. higher rates of predation, higher rates of parasitism, and reductions in pairing success), risk of vehicle collisions with wildlife, illegal poaching and collection, and increased numbers of wildfires. Such disturbances may damage active nesting, roosting, perching, foraging, or denning sites and/or cause such sites to be abandoned.

In addition, the increase in the number of residences and associated developments within the MNF has likely increased wildlife populations associated with human residential areas such as raccoons, opossums, and skunks, which may predate active nest sites. Increases in human development, access, and use also may remove potential nesting, roosting, perching, or denning sites and/or temporarily disturb wildlife searching for new nest, roost, perch, or den sites, limiting the use of potential habitat. Human disturbance may also disrupt the normal foraging behavior of wildlife, limiting the use of foraging areas and potentially affecting productivity. Furthermore, increases in human development, access, and use may decrease the quantity and quality of forest openings, upland areas, and aquatic habitats (e.g. rivers, streams, lakes, ponds, swamps, and wetlands), potentially decreasing the abundance and diversity of forage and prey species, and subsequently reducing foraging habitat and the prey base. Thus, increases in human populations and associated developments and uses could result in the permanent loss and degradation of breeding and

foraging habitat for wildlife associated with mid- to late-successional forest types on private lands within the MNF. This magnifies the importance of NFS lands to these species. Timber harvest, fire suppression, savanna and prairie creation activities, and the application of pesticides also are activities that may adversely affect wildlife species associated with mid- to late-successional vegetative types on private lands within the MNF in the future. In addition, mineral developments are reasonably certain to occur in the foreseeable future within the MNF and have the potential to cumulatively affect wildlife associated with the loss of mature forest habitats.

The amount of mid- to late-successional forest habitat is expected to be reduced under the Forest Plan's management direction in localized areas (USDA 2012c). Management for early successional vegetative types would decrease the amount of mature forest habitat available for northern goshawks, red-shouldered hawks, bald eagles, Louisiana waterthrushes, eastern box turtles, and black bears, and increase the effects of forest fragmentation (such as increased competition from red-tailed hawks or house wrens, predation from raccoons, or nest parasitism by brown-headed cowbirds). Fuel hazard reduction treatments also would likely decrease the amount of contiguous mature forest available for these species.

However, other management directives delineated in the Forest Plan promote mid- to late-seral stages of forest vegetation. Special Areas, Wild and Scenic River designations, rare plant areas, and candidate RNAs would protect hardwood forests, reducing habitat fragmentation. In these areas, there would be fewer roads, less vegetation manipulation, and reduced disturbance from recreational activities. The old growth designation would provide planned old growth in the northern hardwood and long-rotation oak type. In addition, management of the hardwood forest types would continue to provide a stable or increasing amount of mature habitat for wildlife associated with mid- to late-successional forest types, and would provide adequate amounts of regenerating hardwood types for prey habitat. Forestry management practices also emphasize retaining dominant trees in a stand and large snags, while increasing vertical and horizontal forest structure considered important for almost all forest dependent priority species. The amount of pine thinnings, mature oak and aspen forest regeneration, and dead tree salvage treatments is projected to remain at 1979-2005 levels. Thus, overall, the Forest Plan's management directives would provide large blocks of maturing habitat spatially interspersed with early successional vegetative types across the HMNF (providing habitat for early- and late-successional wildlife species). As a result, the amount of mid- to late-successional forest habitat is expected to remain stable at a broad scale across the MNF. In the long term, the overall quality of mid- to late-successional forest habitat would increase as stands matured and tree diameters increased, large woody debris and snags increased, and canopy gaps developed.

The Direct and Indirect Effects of Implementing Alternative 2

Management activities proposed under Alternative 2 may have direct effects on wildlife associated with mid- to late-successional forest types within the Project Area. Opening restoration/maintenance, opening creation, savanna restoration, commercial thinning, overstory removal, broadcast burning, maintenance of in-stream structures, riparian planting, and road/stream crossing improvements, proposed under Alternative 2, may displace or disrupt the normal behavior of bald eagle, Louisiana waterthrush, northern goshawk, red-shouldered hawk, eastern box turtle, and other wildlife associated with mid- to late-successional forest types within the Project Area; less mobile species may be directly affected by being crushed by mechanized equipment or killed during burns. Traffic associated with implementation may temporarily increase the risk of mortality due to vehicle collisions. Vegetative management activities and

vehicle and foot traffic associated with implementation also may temporarily increase the level of disturbance near active nests, potentially resulting in nest abandonment and/or the removal of nest sites. Severe nest site disturbance, such as road building or timber harvest activity, can cause abandonment of nests, particularly during incubation of the eggs (Jacobs 2002; Roberson et al 2003). Timber harvest activity that occurs during the non-nesting season when the birds are not dependent on the site doesn't result in abandonment if the site is not severely changed, such as by a clearcut (Jacobs 2002; Roberson et al 2003).

In addition, ground disturbance within forest openings may reduce the reproductive success of eastern box turtles if nest sites are destroyed. Management activities also may remove denning sites for black bears, and/or temporarily displace, alter movement, or disturb northern goshawks, red-shouldered hawks, bald eagles, Louisiana waterthrushes, eastern box turtles, and black bears, limiting the use of potential breeding and foraging habitat and potentially affecting productivity. Management activities conducted between September and March would largely protect these RFSS species, as it is outside of their breeding and active periods.

Under Alternative 2, strip/patch or spot application of glyphosate, triclopyr, or imazapic would be used to control NNIP and persistent woody vegetation. Wildlife associated with mid- to late-successional vegetative types may be exposed to these herbicides:

1. By direct contact with recently treated foliage;
2. By consuming prey items that have come in direct contact with herbicide spray, recently treated foliage, or consumed parts of treated plants;
3. By consuming treated foliage; or,
4. By drinking from water sources that have received contaminated surface runoff.

As stated above under *Direct and Indirect Effects* for KBB, glyphosate, triclopyr, and imazapic pose little or no risk to wildlife at rates commonly used by the Forest Service, as long as the herbicides are used in accordance with the manufacturer label. The Roundup formulation of glyphosate and butoxyethyl ester formulations of triclopyr are exceptions to this generalization, due to the extremely low LC_{50} values for aquatic species (USDA 2011c; USDA 2011d). However, only formulations labeled for use in aquatic areas would be used within 100 feet of wet areas such as lakes, wetlands, and riparian corridors. Risk assessments for glyphosate and triclopyr conclude that small birds and animals that consume vegetation or insects from areas treated with the maximum application rate for an extended period of time could experience adverse effects. However, this type of treatment would not occur. Because spot and strip/patch application would be used to treat small areas within the Project Area, it would be unlikely that wildlife associated with mid- to late-successional forest types would come in direct contact with recently treated foliage, or would feed solely on prey or plants that have been exposed to herbicide sprays. In addition, consumption of exposed prey would likely have a minimal effect on these wildlife species given that glyphosate, triclopyr, and imazapic are not expected to bio-accumulate in the food chain.

Potential adverse direct effects on wildlife associated with mid- to late-successional forest types would be minimized with the implementation of the conservation measures outline for northern long-eared bat and RFSS in Appendix A within stands where they are documented or found (Table B3 in Appendix B). For example, except for prescribed burning and broadcast burning, these measures would ensure that the timing and spatial pattern of management activities avoid known nesting locations of RFSS birds during the breeding season. These measures would also promote

the retention of key habitat features such as retaining large snags and trees that have cavities. In addition, implementation of the Standards and Guidelines for Watershed Management described in the Forest Plan would reduce the potential for adverse direct effects. For instance, the Guideline stating that equipment should not be operated within the SMZ when soils are saturated or when rutting is likely to occur would limit activities to periods when the soils in the riparian corridor were frozen, such as winter, which would be outside of the nesting seasons and active periods for bald eagle, Louisiana waterthrush, northern goshawk, red-shouldered hawk, and eastern box turtle. To further reduce the potential for adverse effects, the locations of known nests and roosts of these RFSS birds would be flagged or marked, and management activities would be performed carefully to avoid physical injury to such structures and less mobile wildlife, such as the eastern box turtle. If other sensitive wildlife species associated with mid- to late-successional forest types are found during project activities, appropriate protection measures would be implemented to reduce potential adverse effects.

Vegetative management activities, proposed under Alternative 2, would likely have indirect effects on local populations of northern goshawks, red-shouldered hawks, bald eagles, Louisiana waterthrushes, eastern box turtles, black bears, and other wildlife associated with mid- to late-successional forest types through habitat change. Opening restoration/maintenance, opening creation, savanna restoration, commercial thinning, overstory removal, and broadcast burning would reduce the amount of foraging and breeding habitat for these species within the Project Area. Mature forest would be converted to openland habitats (e.g. openings, savannas, prairies) and early successional forest on up to 977 acres under Alternative 2. As a consequence, species dependent on hard mast production (e.g. red-headed woodpecker, wild turkey, squirrels, white-tail deer) would likely experience a reduction in food availability, which may subsequently lead to a reduction in prey availability and abundance for foraging northern goshawks, red-shouldered hawks, bald eagles, and black bears. While opening restoration/maintenance, opening creation, and savanna restoration may reduce hard mast production over the long term, overstory removal and commercial thinning would likely reduce hard mast production over the short term, as stands receiving these treatments would promote the regeneration of hardwoods.

The proposed management activities also may damage vegetation and increase the amount of bare ground within forest openings and upland areas. This may lead to a temporary reduction in native plants that provide food and cover for small mammals, birds, and terrestrial and aquatic insects and a short-term decline in suitable foraging habitat and prey base for northern goshawk, red-shouldered hawk, bald eagle, and Louisiana waterthrush. Reductions in native plants (such as berry producing species) and invertebrates may also temporarily reduce suitable foraging habitat and prey base for eastern box turtle and black bear. However, these potential short term effects would be expected to be minimal, given that human disturbance and associated reductions in foraging habitat would potentially affect only small acreages in localized areas within the Project Area in any given time period. This would allow foraging potential in those areas that remain undisturbed.

In addition, management activities would increase forest fragmentation and the amount of edge, which may reduce the nesting success of forest-interior bird species, such as the northern goshawk and red-shouldered hawk, due to higher rates of predation, higher rates of parasitism, and reductions in pairing success. Fragmentation of forest stands and the creation of larger openings favor the immigration of nest competitors and predators such as the red-tailed hawk and great-horned owl (Cooper 1999a; Cooper 1999b). These species can either displace northern goshawk or red-shouldered hawk nesting pairs or directly depredate young and/or adults from a nest site

(Cooper 1999a; Cooper 1999b). Other effects related to fragmentation include increased parasitism by brown-headed cowbirds, increased nest competition with species such as the house wren, and/or increased predation from species such as raccoons, which may reduce the reproductive success of nesting Louisiana waterthrushes (Gibson 2007b).

While opening restoration/maintenance, opening creation, and savanna restoration would have long term forest fragmentation effects, overstory removal and commercial thinning would produce temporary edges and fragmentation. Thus, any adverse effects from overstory and commercial thinning would likely be short term for species favoring forest interior conditions including northern goshawk and red-shouldered hawk. Reduction of habitat quantity and quality for interior-dependent species would be greatest under Alternative 2. However, because a relatively small percentage (9%) of the Project Area would be affected by vegetative management activities, reductions in foraging and breeding habitat would not likely decrease the overall numbers of wildlife associated with mid- to late-successional forest types within the Project Area.

Vegetative management activities, proposed under Alternative 2, also may have beneficial indirect effects to the foraging and breeding habitat of wildlife associated with mid- to late-successional forest types. Management for openland habitats may increase the quantity and quality of interspersed forest openings and uplands, increasing the availability of native grasses, forbs, and shrubs that provide food and cover for small mammals, birds, and terrestrial insects, subsequently increasing the abundance and diversity of forage and prey species. Availability of prey species also may increase in response to overstory removal and commercial thinning as these treatments would likely increase age-class, structural, and species diversity of trees and shrubs. An increase in open areas within upland forests near waterbodies would also likely increase the availability of suitable nesting areas for eastern box turtle. Overstory removal and commercial thinning also would improve the productivity of forested stands within the Project Area by reducing the impacts of native and non-native insects and diseases on pines and oaks. In addition, broadcast burning may indirectly benefit wildlife associated with mid- to late-successional forest types by:

1. Reducing the potential for wildfire;
2. Damaging or killing trees, contributing to the production of snags, down wood, and potential perch trees; and,
3. By maintaining forest openings that provide nesting or foraging areas for wildlife such as eastern box turtles and northern goshawks.

Overall, vegetative management activities, proposed under Alternative 2, are expected to have both beneficial and negative direct and indirect effects on wildlife associated with mid- to late-successional forest types within the Project Area. Adverse effects would be expected to be minimal with the implementation of the conservation measures listed in Appendix A.

Under Alternative 2, habitat protection measures, activities to repair resource damage (i.e. site rehabilitation via removal of NNIP and trash, and seeding/planting activities), and transportation management activities (i.e. road closures, road construction, road reconstruction) would be implemented to mitigate and reduce environmental impacts from human use within the Project Area. These treatments are expected to have primarily beneficial direct and indirect effects to local populations of wildlife associated with mid- to late-successional forest types within the Project Area, and any adverse direct and indirect effects would be expected to be minimal with implementation of the conservation measures outlined in Appendix A. Reducing the amount of

unclassified roads, closing Forest System roads, and blocking vehicular access to managed openlands may decrease levels of disturbance and reduce the risk of motorized users and other recreational impacts, as described above under the No Action Alternative.

Road closures and treatments to rehabilitate and protect openings, savannas, barrens, prairies, and grasslands with resource damage would likely increase the diversity and abundance of native forbs, grasses, and shrubs, and subsequently forage and prey species, within openlands and along right-of-ways. This may provide additional food resources and improve dispersal corridors for wildlife associated with mid- to late-successional forest types. Over time, the effects of fragmentation and erosion/sediment delivery would be reduced as native vegetation became re-established along closed roads.

Overall, habitat protection, resource damage, and transportation management activities proposed under Alternative 2 would likely decrease the risk of mortality and improve habitat quantity and quality for wildlife associated with mid- to late-successional forest types within the Project Area. Alternative 2 would provide more protection from human access and use than Alternative 3 given that it proposes an additional 1.1 miles of Forest System road closures.

The Cumulative Effects of Implementing Alternative 2

The cumulative effects of activities on non-Federal lands on wildlife associated with mid- to late-successional forest types would be the same as those described under the No Action Alternative. Overall, the effects of the proposed management activities on Federal lands under Alternative 2 are expected to be local and are not likely to have adverse cumulative effects on wildlife associated with mid- to late-successional forest habitats. Given the quantity and quality of suitable habitat for northern goshawk, red-shouldered hawk, bald eagle, Louisiana waterthrush, eastern box turtle, and other forest wildlife species is expected to either remain stable or increase across the MNF under the Forest Plan's management directives, populations of these species also are expected to remain stable or increase over time.

The Direct and Indirect Effects of Implementing Alternative 3

Management activities proposed under Alternative 3 are nearly identical to those proposed under Alternative 2. Therefore, the anticipated direct and indirect effects on wildlife associated with mid- to late-successional forest types within the Project Area would be similar, but slightly less than those under Alternative 2 because mature forests would be converted to openland habitats (e.g. openings, savannas, prairies) and early successional forest on up to 977 acres under Alternative 2, but only 775 acres under Alternative 3.

The Cumulative Effects of Implementing Alternative 3

Cumulative effects under Alternative 3 would be indistinguishable from those described under Alternative 2.

Wildlife Associated with Streams, Creeks, Lakes, and Wetlands

The Direct and Indirect Effects of Implementing Alternative 1

Under this alternative, mid- to late-successional forests would continue to increase within the Project Area due to fire suppression and natural succession. Over time, the quantity and quality of forested habitat would increase along wetlands, riparian areas, and other waterbodies. Tree diameters and dead and down woody debris would increase and canopy gaps would develop. Increases in mature forest with canopy gaps near rivers, streams, creeks, lakes, and wetlands may increase nesting and/or foraging habitat for Blanding's turtle, spotted turtle, wood turtle, and other water-dependent wildlife species. However, if succession leads to the loss of interspersed forest openings, uplands, and/or wetlands, then the availability of suitable nesting and/or foraging habitat for these species may decline despite the development of canopy gaps.

Under Alternative 1, deteriorating road-stream crossings and in-stream large woody debris structures, and a lack of shade trees along riparian corridors, would continue to threaten the water quality of streams and creeks within the Project Area, as described in the Aquatic Section. This alternative also would fail to control Scots pine and other NNIP in the Project Area, which may out-complete and replace native plants that provide food and/or cover for wildlife associated with aquatic habitats. Wildlife species that may experience a decline in habitat quality and quantity due to changes in water quality and increases in invasive species include waterfowl and shorebirds, such as common loon, great blue heron, wood duck, mallard, black duck, and Canada goose, and other water-oriented species including beavers, wood turtle, spotted turtle, and Blanding's turtle. Forage and prey species important to water-dependent wildlife such as aquatic insect species also may decline. However, this potential adverse effect would likely be minimal due to the small acreages affected.

Habitat quantity and quality for wildlife associated with streams, creeks, lakes, and wetlands also may decline under Alternative 1 because it would maintain current road and trail densities, and thus human access and use, within the Project Area. Numerous oil/gas pipeline and power line right-of-ways intersect roads and trails within the Project Area, and are commonly used travel routes by ORVs. Resource damage from unapproved recreational activities, the primary one being ORV use, has been documented on NFS lands within the Project Area, particularly user created roads that provide access to water bodies.

Vehicle use, foot traffic, horseback riding, and dispersed camping causes disturbance of wildlife, increased risk of ground nests of Blanding's turtles, spotted turtles, and wood turtles being destroyed, vehicle collisions with wildlife, illegal collection, and increased potential of wildfires. Such disturbance may damage and/or cause the abandonment of common loon, bald eagle, great blue heron, wood duck, mallard, black duck, or Canada goose roost or nest sites, and disrupt the normal nesting and foraging behavior of wildlife associated with aquatic habitats, limiting the use of nest sites and foraging areas and potentially affecting productivity. Road and trail traffic also may:

1. Damage or destroy hibernacula and forage plants;
2. Lead to an increase in mammalian predators associated with human activities;
3. Increase nest predation near habitat edges via habitat fragmentation;
4. Introduce and spread NNIP;
5. Increase soil disturbance, erosion, compaction, and the amount of bare ground; and/or,

6. Reduce water quality in rivers, streams, creeks, lakes, and wetlands via increased erosion or sediment delivery.

Thus, maintaining current levels of access and use may increase the risk of mortality, reduce available breeding and foraging habitat, and limit the use of nesting and foraging areas for Blanding's turtles, wood turtles, spotted turtles, common loons, and other wildlife associated with aquatic habitats. This would potentially affect the survivorship and reproductive success of these species. Overall, Alternative 1 is expected to have adverse direct effects, and beneficial and adverse indirect effects on wildlife associated with aquatic habitats.

The Cumulative Effects of Implementing Alternative 1

Increases in human populations and associated land development, road construction, and recreational uses are expected on private lands within the HMNF. These activities would likely increase the potential for human access and use within or adjacent to aquatic habitats used by wood turtles, Blanding's turtles, spotted turtles, common loons, and other wildlife associated with aquatic habitats (e.g. great blue heron, wood duck, mallard, black duck, Canada goose, and beaver). Increased human access and use may lead to increased levels of disturbance (e.g. human activity, noise, and habitat degradation), the risk of vehicle collisions with wildlife, illegal poaching and collection, and increased numbers of wildfires. Such disturbance may reduce productivity by damaging nesting, roosting, or foraging sites and/or causing such sites to be abandoned, disrupting the movements and normal behavior of individual animals, and/or increasing predation by mammalian predator populations that are associated with human activities (e.g. raccoon, opossum, skunks). Development of residences near lakeshores and stream sides could also reduce habitat quantity and quality through the actual destruction of nesting sites, hibernacula, cover, and/or important plant species that provide food (e.g. foliage, fruit) for water-oriented wildlife or their prey. Such developments could also increase habitat fragmentation and reduce water quality in streams and lakes via increased soil erosion or sediment delivery. Timber harvest, fire suppression, mowing, savanna and prairie creation activities, ORV and motorboat use, and the application of pesticides are also activities that may adversely affect wildlife associated with aquatic habitats on private lands. In addition, mineral developments are reasonably certain to occur in the foreseeable future within the MNF and have the potential to cumulatively affect wildlife associated with aquatic habitats. Overall, habitat quantity and quality for wildlife associated with aquatic habitats, and subsequent occurrences of these species, would likely decline on private lands within the MNF. With increasing development and fragmentation of private lands, suitable habitat for wildlife associated with aquatic habitats on NFS lands within the MNF is likely to become more important in the future.

Under the direction of the Forest Plan (USDA 2012c), management actions to improve watershed condition would continue elsewhere within the HMNF, focusing on erosion control, upgrading road stream crossings, lowering road densities, improving in-stream and lake habitat, and maintaining riparian buffer zones. As the forest continues to mature, more large woody debris input into streams and lakes would occur. Large woody debris can protect stream banks from erosion, provide habitat for aquatic insects, provide cover for fish, and provide habitat diversity. Management for early successional vegetative types, as directed by the Forest Plan (USDA 2012c), would decrease the amount of mature forest habitat in localized areas. Although this would lead to more open space within the watersheds located within the HMNF, there should be a minimal effect on runoff and flow regimes because all of the sixth level watersheds will still have more than 33% of their area in a mature forest (>20 year age class) condition. While increases in

human populations and associated land uses and developments are expected within the MNF in the future, the positive effects of planned watershed management activities on the Forest should mitigate the negative effects of activities on private lands. Overall, there should be an improvement in water quality, aquatic habitat, and watershed health within the watersheds located within the HMNF.

The Direct and Indirect Effects of Implementing Alternative 2

Opening restoration/maintenance, opening creation, savanna restoration, commercial thinning, overstory removal, broadcast burning, maintenance of in-stream structures, riparian planting, and road/stream crossing improvements, proposed under Alternative 2, may kill, displace, or disrupt the normal behavior of wood turtles, spotted turtles, Blanding's turtles, common loons, and other wildlife associated with aquatic habitats (e.g. great blue heron, wood duck, mallard, black duck, Canada goose, and beaver) if management activities occur near rivers, streams, creeks, lakes, or wetlands. Management activities and vehicle and foot traffic associated with implementation may increase the risk of mortality due to vehicle collisions with wildlife, and temporarily increase the level of disturbance near nest, roost, or hibernation sites. This would potentially result in the abandonment and/or removal of such sites, destroy unhatched eggs, and/or kill immobile young or dispersing neonate turtles, reducing reproductive success. Management activities also may temporarily disturb Blanding's turtles, wood turtles, spotted turtles, common loons, and other water-oriented wildlife species searching for sunning, foraging, roosting, nesting, and hibernation sites, limiting the use of breeding and/or foraging habitat and potentially affecting productivity. Because Blanding's turtles, wood turtles, and spotted turtles are characterized by delayed sexual maturity, small clutch size, low reproductive success, high adult survival rates, and long adult lives, in order to maintain stable populations, these species require high annual survivorship of adults and juveniles (Lee 1999a; Lee 1999b; Lee 2000). Population declines and local extirpations may occur if mortality or removal of adults and juveniles occurs at a rate faster than they can be replaced over time (Lee 1999a; Lee 1999b; Lee 2000).

Wildlife species that have limited mobility and/or are breeding would be most likely to be directly affected in these operations due to heavy equipment use and prescribed burning. Management activities are more likely to have an adverse direct effect on the wood turtle, spotted turtle, and Blanding's turtle if implemented near aquatic habitats between late spring to early fall when these species increase their use of adjacent uplands and forests for foraging, mating, and/or nesting (Lee 1999a; Lee 1999b; Lee 2000). Between late fall and early spring, direct effects on these RFSS are expected to be insignificant as Blanding's turtles, spotted turtles, and wood turtles spend the majority of their time in aquatic habitats (Lee 1999a; Lee 1999b; Lee 2000), which would largely protect them from any direct impacts. Nest site selection and nest success of common loons is most likely to be adversely affected by management activities that occur between May and July (Gibson 2007a; Tischler 2011).

Alternative 2 proposes strip/patch or spot application of glyphosate, triclopyr, or imazapic to control NNIP and persistent woody vegetation. Wildlife associated with aquatic habitats may be exposed to these herbicides by: direct contact with recently treated foliage; by consuming treated foliage or prey items that have come in direct contact with herbicide spray, recently treated foliage, or consumed parts of treated plants; or by drinking from or swimming in water sources that have received contaminated surface runoff. However, as stated above under *Direct and Indirect Effects* for KBB, glyphosate, triclopyr, and imazapic pose little or no risk to wildlife at rates commonly used by the Forest Service, as long as they are used in accordance with the manufacturer label

(USDA 2004b; USDA 2011c; USDA 2011d). Due to the extremely low LC_{50} values for aquatic species, the Roundup formulation of glyphosate and butoxyethyl ester formulations of triclopyr are exceptions to this generalization (USDA 2011c; USDA 2011d). To protect water-oriented wildlife, only formulations labeled for use in aquatic areas would be used within 100 feet of wet areas such as lakes, wetlands, and riparian corridors. Although risk assessments for glyphosate and triclopyr conclude that small birds and animals that consume vegetation or insects from areas treated with the maximum application rate for an extended period of time could experience adverse effects, this type of treatment would not occur. Because spot and strip/patch application would be used to treat small areas within the Project Area, it would be unlikely that wildlife associated with aquatic habitats would come in direct contact with recently treated foliage, would feed solely on prey or plants that have been exposed to herbicide sprays, or would be exposed to contaminated water sources. In addition, consumption of exposed prey would likely have a minimal effect on these species given that glyphosate, triclopyr, and imazapic are not expected to bioaccumulate in the food chain (USDA 2004b; USDA 2011c; USDA 2011d).

To minimize potential adverse direct effects Alternative 2 may have on Blanding's turtle, wood turtle, spotted turtle, common loon, and other wildlife associated with aquatic habitats, conservation measures outlined in Appendix A would be implemented within stands where these species are documented or found (Table B3 in Appendix B). For example, these measures would protect nesting common loons by planning management activities outside of the breeding season and buffering nest locations. The timing and spatial pattern of management activities also would avoid the activity periods and breeding habitats of Blanding's turtles, spotted turtles, and wood turtles. The potential for direct effects also would be reduced by the Guideline stating that equipment should not be operated within the SMZ when soils are saturated or when rutting is likely to occur (USDA 2012c). This would limit activities to periods when the soils in the riparian corridor are frozen, such as winter, which would correspond to the inactive period of reptilian species and would be outside the nesting season of waterfowl and shorebirds. In addition, the nesting locations of common loon would be marked and protected via the installation of signs and temporary closure orders, and management activities would be performed carefully to avoid physical injury to less mobile wildlife, such as Blanding's turtle, wood turtle, and spotted turtle. If other sensitive wildlife species associated with aquatic habitats are found during project activities, appropriate protection measures would be implemented to reduce potential adverse effects.

Vegetative treatments, road system activities, and aquatic habitat improvements, proposed under Alternative 2, would likely have indirect effects on local populations of Blanding's turtle, wood turtle, spotted turtle, common loon, and other water-oriented wildlife through habitat change. Management activities and vehicle and foot traffic associated with implementation may damage vegetation and increase the amount of bare ground within treated lowland and upland openings near rivers, streams, creeks, lakes, and wetlands, temporarily decreasing cover and the abundance of important forage species and prey species, such as herbs, wildflowers, berry producing shrubs, invertebrates, and small animals. Increased habitat fragmentation near water bodies also may result from project implementation, potentially reducing productivity due to increased nest predation near habitat edges. Management activities, particularly prescribed burning, may also reduce dead and down woody debris that provides structure for thermal regulation and protection from predators. In addition, treatments near wetlands, small tributaries, or ponds may temporarily reduce water quality via increase erosion and sediment delivery, resulting in a short-term decrease in habitat quality and quantity for water-oriented wildlife species, and subsequently population numbers.

The proposed management activities also would likely have beneficial indirect effects to the foraging and breeding habitat of Blanding's turtles, wood turtles, spotted turtles, common loons, and other wildlife associated with streams, creeks, lakes, and wetlands. For instance, prescribed burning may indirectly benefit water-oriented wildlife species by reducing the potential for wildfires. Management for early successional vegetative types may increase the quantity and quality of interspersed forest openings and uplands, increasing the availability of sunning and nesting areas, and increasing native grasses, forbs, and berry producing shrubs (i.e. increasing the abundance and diversity of forage species). In addition, control of NNIP may increase native species richness and diversity, increasing available for food and cover for wildlife associated with aquatic habitats.

Maintenance of in-stream structures, riparian planting, and road/stream crossing improvements would likely improve the health of aquatic systems within the Project Area. In stream structures may increase habitat diversity and cover for fish, invertebrates, reptiles and other components of the aquatic food chain, add nutrients to the aquatic system, protect stream banks during high flow events, and increase resting and basking opportunities for reptiles. Management of riparian corridors via plantings may improve water quality by reducing stream temperatures and provide cover for wildlife. Improvement of road-stream crossings may reduce erosion, sediment inputs, and chemical inputs. The replacement or rehabilitation of culverts also may maintain or improve passage for aquatic organisms at road crossings, which would benefit turtles and other water-oriented species by reducing inhibition of movement within aquatic ecosystems, providing access to additional areas of suitable habitat, and by improving genetic flow and exchange between sub-populations within the Forest. Improvements in habitat quality and quantity may lead to an increase in local populations of waterfowl and shorebirds, such as common loon, great blue heron, wood duck, mallards, black duck, and Canada geese, and other water-oriented species including beavers, wood turtle, spotted turtle, and Blanding's turtle, which may increase prey populations for predators like the bald eagle.

Overall, vegetative management activities under Alternative 2 are expected to have adverse and beneficial direct and indirect effects on wildlife associated with aquatic habitats within the Project Area, and any adverse effects are expected to be minimal with implementation of the conservation measures listed in Appendix A.

Habitat protection measures, activities to repair resource damage, and transportation management activities, proposed under Alternative 2, would have primarily beneficial direct and indirect effects to local populations of Blanding's turtle, wood turtle, spotted turtle, common loon, and other wildlife associated with aquatic habitats within the Project Area. Closing Forest System roads, reducing the amount of unclassified roads, and blocking vehicular access to vulnerable openland and aquatic habitats may decrease levels of disturbance and reduce the risk of motorized users and other recreational impacts, as described above under the No Action Alternative. Road closures and treatments to rehabilitate and protect areas with resource damage would likely enhance openlands and aquatic habitats within the Project Area, increasing the availability of sunning and nesting sites and the abundance and diversity of forage and prey species. As native vegetation becomes re-established along closed roads, the effects of fragmentation and erosion and sediment delivery would likely be reduced and dispersal corridors would improve.

Overall, habitat protection, resource damage, and transportation management activities proposed under Alternative 2 would likely decrease the risk of mortality and improve habitat quantity and quality for wildlife associated with aquatic habitats within the Project Area. Because Alternative 2

proposes an additional 1.1 miles of Forest System road closures, it would provide more protection from human access and use than Alternative 3.

The Cumulative Effects of Implementing Alternative 2

Cumulative effects of activities on non-Federal lands on water-oriented wildlife would be the same as those described under the No Action Alternative. The effects of the proposed management activities on Federal lands under Alternative 2 are expected to be local and are not likely to have adverse cumulative effects on wildlife associated with aquatic habitats. Suitable habitat for wood turtles, spotted turtles, Blanding's turtles, common loons, and other water-oriented wildlife species is expected to either remain stable or increase on Federal lands across the MNF under the Forest Plan's management direction, as watershed management activities are implemented to improve water quality, aquatic habitat, and watershed health.

The Direct and Indirect Effects of Implementing Alternative 3

Management activities proposed under Alternative 3 are nearly identical to those proposed under Alternative 2, with the following exceptions. Commercial thinning and broadcast burning would occur on 3,085 acres under Alternative 2, whereas these vegetative treatments would occur on 2,978 acres under Alternative 3. In addition, mature forests would be converted to openland habitats and early successional forests on up to 775 acres under Alternative 3 versus 977 acres under Alternative 2. Because vegetative treatments would be conducted on a smaller number of acres under Alternative 3, the anticipated direct and indirect effects on wildlife associated with aquatic habitats within the Project Area would be similar, but slightly less than those under Alternative 2.

The Cumulative Effects of Implementing Alternative 3

The cumulative effects of proposed treatments under Alternative 3 would be indistinguishable from those described under Alternative 2.

Determination of Effects for Threatened, Endangered, and Sensitive Wildlife Species

A BA and BE was prepared for the Bigelow-Newaygo Project (see Planning Record) that documented the determinations of effects of the Bigelow-Newaygo Project on federally-listed and Proposed Endangered and Threatened species, RFSS, and State-listed Endangered or Threatened species by each alternative. There is no federally designated critical habitat in the Project Area; therefore, none would be affected. Eighteen wildlife species that may be present or have habitat within the Project Area were analyzed in these documents including: KBB, northern long-eared bat, dusted skipper, Persius duskywing, frosted elfin, Ottoe skipper, hill-prairie spittlebug, prairie warbler, red-headed woodpecker, bald eagle, Louisiana waterthrush, common loon, northern goshawk, red-shouldered hawk, eastern box turtle, wood turtle, spotted turtle, and Blanding's turtle. The effect determination by species is listed below in Table 3-52. The determinations were made contingent on implementation of the conservation measures listed in Appendix A. The conservation measures would be implemented with Alternatives 2 and 3.

Determination of Effects for Threatened, Endangered, and Sensitive Wildlife Species that May Occur within the Bigelow-Newaygo Project Area

Table 3-52

Common Name	Species Name	Status	Alternative 2	Alternative 3
Karner blue butterfly	*Lycaeides melissa samuelis (Nabokov) [or Plebejus melissa (Edwards 1873)]*	Federally Endangered	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Northern long-eared bat	*Myotis septentrionalis*	RFSS; Proposed Federal T&E	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Dusted skipper	*Atrytonopsis hianna*	RFSS; State Species of Concern	MINT	MINT
Hill-prairie spittlebug	*Lepyronia gibbosa*	RFSS; State Species of Concern	MINT	MINT
Frosted elfin	*Incisalia irus*	RFSS; State Threatened	MINT	MINT
Persius duskywing	*Erynnis persius persius*	RFSS; State Threatened	MINT	MINT
Ottoe skipper	*Hesperia ottoe*	Former RFSS; State Threatened	MINT	MINT
Red-headed woodpecker	*Melanerpes erythrocephalus*	RFSS; Protected under the Migratory Bird Treaty Act of 1918 (MBTA)	MINT	MINT
Prairie warbler	*Dendroica discolor*	RFSS; State Endangered; Protected under the MBTA of 1918	MINT	MINT

Common Name	Species Name	Status	Alternative 2	Alternative 3
Bald eagle	*Haliaeetus leucocephalus*	RFSS; State Species of Concern; Protected under the MBTA of 1918 and the Bald and Golden Eagle Act of 1940	MINT	MINT
Common loon	*Gavia immer*	RFSS; State Threatened; Protected under the MBTA of 1918	MINT	MINT
Louisiana waterthrush	*Seiurus motacilla*	RFSS; State Threatened; Protected under the MBTA of 1918	MINT	MINT
Northern goshawk	*Accipiter gentilis*	RFSS; State Species of Concern; Protected under the MBTA of 1918	MINT	MINT
Red-shouldered hawk	*Buteo lineatus*	RFSS; State Threatened; Protected under the MBTA of 1918	MINT	MINT
Eastern box turtle	*Terrapene carolina carolina*	RFSS; State Species of Concern	MINT	MINT
Spotted turtle	*Clemmys guttata*	RFSS; State Threatened	MINT	MINT
Blanding's turtle	*Emys blandingii*	RFSS; State Species of Concern	MINT	MINT
Wood turtle	*Glyptemys insculpta*	RFSS; State Species of Concern	MINT	MINT
Status RFSS = Regional Forester Sensitive Species			Determinations MINT = May impact individuals or sub-populations, but not likely to cause a trend towards federal listing or loss of viability.	

CHAPTER 4
LISTS

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Acronyms

APE	Area of Potential Effect
ASQ	Allowable Sale Quantity
ATV	All-Terrain Vehicle
BA/BE	Biological Assessment/Biological Evaluation
BBS	Breeding Bird Survey
BMA	Bigelow Metapopulation Area
BMP	Best Management Practices
BTU	British Thermal Unit
BWC	Baldwin-White Cloud
CFR	Code of Federal Regulations
CMAI	Culmination of Mean Annual Increment
CWPP	Community Wildfire Protection Plan
DBH	Diameter at Breast Height
DFC	Desired Future Condition
EA	Environmental Assessment
ELTP	Ecological Land Type Phase
EPA	Environmental Protection Agency
ESA	Ecological Study Area
ESA	Endangered Species Act
FQA	Floristic Quality Assessment
FQI	Floristic Quality Index
FSH	Forest Service Handbook
FSM	Forest Service Manual
GHG	Greenhouse Gas
HMNF	Huron-Manistee National Forests
HUC	Hydrologic Unit Code
IDT	Interdisciplinary Team
KBB	Karner Blue Butterfly
LRMP	Land Resource and Management Plan
LSC	Land Suitability Class
LTA	Land Type Association
MA	Management Area
MBTA	Migratory Bird Treaty Act
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MIS	Management Indicator Species
MNF	Manistee National Forest
MNFI	Michigan Natural Features Inventory
MVUM	Motor Vehicle Use Map
NCT	North Country Trail
NEPA	National Environmental Policy Act
NFS	National Forest System
NNIP	Non-native Invasive Plant
NWCG	National Wildfire Coordinating Group
ORV	Off-road Vehicle
RFSS	Regional Forester Sensitive Species

RNA	Research Natural Area
SMP	Smoke Management Program
SMZ	Streamside Management Zone
WUI	Wildland Urban Interface