Terrestrial Ecosystem Components

Introduction

This section discusses the Current Conditions, Current Management Direction, Comparison to Range of Natural Variability (RNV), Proposed Changes and Range of Changes, Direct and Indirect Effects, and Cumulative Effects related to terrestrial ecosystems. Terrestrial ecosystem components addressed under each heading include the following physical and biological elements:

- Ecosystem Vegetative Composition, Structure, and Function
- Non-native Invasive Species (NNIS)
- Ecological Classification and Soils
- Air Quality

Discussion of each component is divided into headings such as "Current Conditions," "Current Management Direction," etc. Assumptions for the section entitled "Comparison of Present Conditions to Range of Natural Variability (RNV)" are found in the Introduction to Chapter 3. Wildlife, Management Indicators, and Threatened, Endangered, and Regional Forester Sensitive Species are addressed in separate sections of this chapter.

Current Conditions

Ecosystem Vegetative Composition, Structure, and Function

Current terrestrial ecosystem conditions on the Chequamegon-Nicolet National Forests resulted from early 1800s EuroAmerican settlement followed by cutover, fires, recovery and present day landscape management (Mladenoff and Pastor 1993; Crow et al. 1994; WDNR 1995d; USDA Forest Service 1998a; Schulte et al. 2002; WDNR 2002a). Today's forests are simplified in composition and structure, and functional components present in earlier times are now altered or lacking (Crow et al. 1994; Mladenoff and Pastor 1993; WDNR 2002a) (See *Comparison of Current Conditions to Estimates of Natural Variation*, below).

See Table 3-59 in *Timber Products, Current Condition* for current species composition of upland forest types on the Forests. Rare natural communities include Pine Barrens, northern dry forests, northern dry-mesic forests, and boreal forests (USDA Forest Service, 2000c; WDNR, 2002a). Hemlock, white pine, and yellow birch are poorly represented in sugar maple dominated hardwoods (Mladenoff and Pastor 1993, Crow et al. 1994). Sand country pineries are forested by red oak, red maple, paper birch, and aspen (WDNR 1995).

The viability of northern white cedar, hemlock, yellow birch, elm, butternut, and white pine are of concern (USDA Forest Service, 1998a; USDA Forest Service, USDA-FS, 2000c; WDNR, 2002a). Elm and butternut were attacked by Dutch elm disease and Butternut canker and then salvage harvested. Past logging practices reduced seed sources for white pine, hemlock, and northern white cedar, while deer herbivory has negatively affected regeneration. Simplification of the ground layer flora is also occurring (Rooney et al. 2002), possibly due to deer herbivory, timber management, and invasion by Non-native species (USDA Forest Service, 1998a; USDA Forest Service, AMS for Ecosystem Restoration, 2000c; Crow et al. 2002a and b; USDA Forest Service, 2002d). Essentially,

plant communities are becoming more simplified and homogenized (Mladenoff and Pastor 1993; Crow et al. 2002a).

Simplification of stand structure is partially exemplified by the presence of fewer large standing and downed trees and fewer tip-up mounds than were present in these northern forests in the historic past. Simplified shrub layers also provide less diverse structure than was present earlier, and some species like Canada yew are a serious viability concern (Crow et al. 2002a; WDNR 2002a).

Disturbance regimes at all scales are dominated by timber management, road and dam building, and development. Non-native invasive species can also change species composition and alter structure, function and processes in natural communities (Randall 1996). Non-native pests like gypsy moth and oak wilt are changing disturbance regimes (USDA Forest Service 1998e; WDNR, 2002a). There is some concern over declining ecosystem functions like pollination and seed dispersal (Rooney et al. 2002).

Non-native Invasive Species

Non-native invasive plant species (NNIS) have infested 100 million acres in the U.S. and infest an additional 3 million acres every year (National Invasive Species Council 2001). Ecologically, invasive species are the second leading threat to Threatened and Endangered species in the United States, negatively affecting up to 46% of the federally listed species (Wilcove et al. 1998). They can invade healthy native ecosystems and in some instances radically alter system functions and processes. Other effects include the loss of biological diversity and wildlife habitat, disruption of fire and nutrient cycles, and the alteration of soil properties. Economically, invasive species are estimated to cost $137 billion a year in lost production and control and management costs, with NNIS plants costing $13 billion a year or more (National Invasive Species Council 2001). Some NNIS plants can cause health problems, from skin rashes and photo-dermatitis to poisoning of livestock, pets, and humans. The spread of NNIS threatens every aspect of ecosystem health and productivity, and occurs across public and private lands (USDA Forest Service 1998e).

Analysis of Chequamegon-Nicolet National Forests flora shows that, of the known plant species on the Forests, 15% (172 species) are not native to northern Wisconsin. Forest plant ecologists identified 17 species (10% of the Non-native plant species on the Forests) as NNIS threats because they have invasive characteristics and pose a threat for native communities and species on the Forests (USDA Forest Service 2002d).

Table 3-10 displays Non-native Invasive Plant Species on the Chequamegon-Nicolet by number of occurrences and total acres of infestation for 2002.

Table 3-10. Non-native Invasive Species

Species	Occurrences	Acres on Forest
Leafy spurge, *Euphorbia esula*	17	7
Canada thistle, *Cirsium arvense*	294	412
Purple loosestrife, *Lythrum salicaria*	9	1.42
Common buckthorn, *Rhamnus cathartica*	5	30.5
Glossy buckthorn, *Rhamnus frangula*	1	>1
Asiatic honeysuckles, *Lonicera tartarica, L. morrowii, and L. x bella*	13	31
Garlic mustard, *Alliaria petiolata*	16	9
Spotted knapweed, *Centaurea biebersteinii* (other *Centaurea* species possible)	271	516
Eurasian water milfoil, *Myriophyllum spicatum*	1	2,714 *
Japanese barberry, *Berberis thunbergii*	5	26
Swamp thistle, *Cirsium palustre*	10	1
Reed canary grass, *Phalaris arundinacea*	25	45
Siberian pea, *Caragana arborescens*	1	5
Black locust, *Robinia pseudo-acacia*	1	>1
St. John's-wort, *Hypericum perforatum*	83	59
Common tansy, *Tanacetum vulgare*	70	51
Total NNIS	821	1,195.92

**2,714 = Total Lake size. EWM only found in small amounts.*

Leafy spurge was found on three districts, mostly along roadsides. However, there are two patches of great concern. One patch in the Moquah Barrens wildlife area is threatening barrens restoration, and the other large patch is invading habitat for a species included on the Regional Foresters Sensitive Species (RFSS) list. Canada thistle seems to be moving along roadsides into northern Wisconsin and onto the Forests from east to west. Swamp thistle was found in wetland conifer stands. Purple loosestrife has been planted as an ornamental garden plant on private property and has spread across lakes and down streams to Forest wetlands. The majority of NNIS shrubs were found at old homestead sites on the Forests or close to urban interface areas where they have been spread by birds. Honeysuckles are also found along major Forest roads. Garlic mustard has moved north from Illinois to southern Wisconsin and now is showing up in recreation sites on the Forests such as campgrounds, trailheads, and along trails. It is probably spread by Recreational Vehicles, ATVs, hiking boots and other recreational equipment. Recreational equipment is also the likely cause of spread for aquatic NNIS like Eurasian water milfoil that can be transported on boats and trailers. Spotted knapweed is found on the Forests along roadsides and in open sandy habitats. Inspections found spotted knapweed growing in some Forest gravel pits and inadvertently spread along Forest roads during road building and maintenance operations. Other open grassland invaders like St. John's-wort and tansy are also found in gravel pits and along Forest roadsides. Although they have not yet invaded critical habitat, these plants do pose a threat to openings, grasslands, and barrens. Reed canary grass is very invasive and is taking over open lowland areas including roadside ditches and old fields surrounding the Northern Great Lakes Visitor Center in Ashland.

Treatment of the above listed NNIS species consists of project designs or mitigations to try to limit the spread of NNIS, some mechanical treatment, and one biological control site. Mechanical treatments include hand pulling and cutting where most cost efficient and effective. Biocontrol beetles were released at the Round Lake purple loosestrife site in a partnership with the WDNR and Pike Lake Association. To date the beetles have been very effective. In general, herbicides are not used on the Chequamegon-Nicolet

National Forests, so that tool is unavailable at this time; however the use of herbicides to treat NNIS is currently being considered.

Soils

The glacial geology and soil resources of the Chequamegon-Nicolet National Forests are characterized within the National Hierarchical Framework of Ecological Units (Cleland et al. 1997). This land classification system sets the context of the landforms, soil resources, and natural vegetation in and next to the Forests, at multiple scales. At the Ecoregion scale the Forests are within the Laurentian Mixed Forest (Province 212), along with the northern portions of Wisconsin, Michigan, and Minnesota. At the Subregion scale the Forests are divided into 6 Sections and 14 Subsections based on climate, glacial geology, soils and potential plant community information.

Ecological units at the landscape level of the hierarchy (Land Type Association or LTA) best delineate the affected environment for soil resource issues for Forest-wide planning. LTAs are ecological units delineated based on similar patterns of glacial landforms, topography, soil complexes and associated patterns of vegetation and succession, within climatic regions. The Forests contain portions of 27 LTAs characterized in detail for their geology, soils, disturbance patterns, historical/existing and potential vegetation, hydrology, fauna, and other ecological attributes. Boundary lines for Management Area (MA) 1-4 polygons were delineated based on LTA mapping and information as part of the Forest plan revision process. Management Area emphases were applied to different polygons to provide a range of actions across Alternatives 2-9 and the Selected Alternative that are consistent with existing and potential resource conditions.

Generally, Forest topography is level to rolling, with 5% to 20% slopes. Steep slopes (>30%) do occur in some areas, but occupy less than 0.5% of the Forests. Elevation changes across the Forests can exceed 300 meters.

Glacial deposits from six lobes of the Laurentide ice sheet provide the parent material for the soils in northern Wisconsin. Common glacial landforms on the Forests include ground moraine, drumlins, end moraine, eskers, and outwash plains. Varying depths of windblown sediments consisting of fine sand or silt have been deposited over these glacial landforms. The integrated effects of climate and living organisms (plants and animals) on these parent materials, as conditioned by the slope and aspect components of topography over the last 10,000 years, has created the existing soil resources of the Chequamegon-Nicolet. Depth of soil over bedrock averages 15 meters and ranges from 0-120 meters.

Soil resources across the 1.5 million acre Chequamegon-Nicolet are complex with a wide variety of soil types identified. Detailed ecological units were mapped at the Land Type and Land Type phase scales of the national hierarchy to provide information for project level analysis. County Soil Surveys completed by the Natural Resources Conservation Service are used in conjunction with ecological map unit information for site-specific interpretations. Nutrient rich, mesic, silt loam soils comprise about 22% of the Forest land base; medium nutrient, dry-mesic, sandy loam soils comprise about 34%; nutrient poor, dry, sandy soils comprise about 16%; and wet mineral and organic soils comprise about 28% of the Forest land base.

The inherent productivity of the Forests' soils evolved with disturbance. Windstorm, fire, drought, flood, and erosion occurred at various spatial and temporal scales associated with climate and related plant community fluctuations. These natural disturbance regimes, along with human disturbance, have affected the physical, chemical, and

biological properties of the soil. Natural disturbance patterns are described in Forest LTA characterizations. Management Area Prescriptions in both the 1986 plan and the 2004 Forest Plan describe potential anthropogenic ground disturbing activities.

Land Type Associations where soil quality was impaired by historical activities such as intensive logging and repeated fires have since re-vegetated naturally or through tree planting. Ground cover and organic matter have controlled erosion and restored nutrient levels over the last 70-100 years. Vegetation on abandoned roads and railroad beds has grown up, and adversely compacted soil is often no longer evident. In many cases old roads are still part of the Forests' existing transportation system. Currently, there are no large areas identified within the Forests where productivity of the land has been permanently impaired due to historical activities.

Carbon storage in vegetation and soil was reduced on LTAs by historic activities such as intensive harvesting, wildfires, and conversion to agriculture or brush land. Grigal and Ohmann (1992, p 937) found most terrestrial carbon in the Lake States is stored in the upper meter of mineral soil (55%) and the forest floor (9%). These values are very similar to those estimated for carbon storage in the average U.S. forest, with 59% in the mineral soil and 9% in the forest floor (Birdsey and Heath, 1997, p 81). Thus, the physical soil resource is an important factor in the global, regional, and landscape scale carbon budget. The CNNF is maintaining the forest floor and mineral soil layers during management activities.

In the 1930's, users developed an off-road/off-trail play area for motorized vehicles on the Washburn District of the Chequamegon National Forest that took advantage of the area's steep, sandy hillsides and open terrain. This same area, although expanded to about 35 to 40 acres, is now known as ATV Play Area "Open 26." In the years since its creation, use of the play area has shifted from motorcycles and full size vehicles to ATV's and snowmobiles. Through the years, more user-developed hill climb routes have been established, expanding the size of the area. Excessive use has caused erosion of the sandy soils and destruction of vegetation, creating deep and unstable trail chutes. As early as 1993, soil scientists predicted that hill-climb trails were "eroding and cutting deeper into the hillside as time goes on" (Olson and Kempf 1993). An additional report, (Olson 1997) states that one "run which splits into 3 half way up the hill has reached the point where it is near beyond repair, and has become dangerous to users." Over time, resource damage has continued.

Carbon in the atmosphere is increasing from burning fossil fuels and changes in terrestrial ecosystem land use. The major terrestrial source is tropical ecosystem destruction through land clearing. While more study of the global carbon cycle is needed, recent studies show the non-tropical terrestrial ecosystem roughly in carbon balance. Some analysts suggest forest ecosystems in the temperate regions may be a sink rather than a source (Armentano and Ralston 1980; Schimel et al. 1994). This is attributed to increasing total forest biomass, soil carbon, and forest floor carbon-sequestering litter. USDA Forest Service timber inventories for the past four decades indicate a continuous increase in net timber volume on federal lands (growth in biomass exceeds removal). Birdsey and Heath (1997, p 82) noted that U.S. forests have been a significant carbon sink since 1952 and that additional carbon will continue to be sequestered through 2040, although at a slower rate.

Except for the ATV Play Area described above, field monitoring of soil impact indicators shows no large areas of long-term impairment of the soil resource from recent activities (USDA Forest Service, 1998d, p 65). When management activities are found to adversely

affect soil resources of a specific area beyond acceptable limits, the condition is corrected through closure and restoration or maintenance. Examples are road/stream crossings where erosion and sedimentation has occurred, or motorized trails and play areas where excessive use has caused soil degradation.

Current conditions for soil properties that affect ecosystem health (i.e. porosity, organic matter content, and nutrient availability) are representative of the natural range of soil conditions inherent to the Chequamegon-Nicolet National Forests (USDA Forest Service, 1998d, p 6). There are healthy populations of soil microorganisms such as bacteria and fungi in the forest litter and soil surface layers.

After 15 years of Chequamegon and Nicolet Forest Plans implementation, there is a trend toward reducing ground disturbing activities such as road construction, timber harvest, and mechanical site preparation. In addition, road closures and obliterations are increasing in an effort to reduce forestwide road density.

Air Quality

The Clean Air Act required the Environmental Protection Agency (EPA) to identify common air pollutants that could endanger public health and welfare as well as develop National Ambient Air Quality Standards (NAAQS) for each of these criteria pollutants. Six criteria pollutants have been identified thus far including particulate matter (PM_{10}), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), nitrogen oxides (NO_x) and lead (Pb). Areas of the country that violate these standards are designated as non-attainment areas. States are required to develop a detailed State Implementation Plan (SIP) that specifies how the NAAQS will be achieved and maintained. Activities of federal agencies must conform to the appropriate SIP. EPA has promulgated rules for determining federal conformity in non-attainment areas.

The 1977 amendments to the Clean Air Act contained provisions for a Prevention of Significant Deterioration (PSD) program to prevent new stationary industrial sources from causing a significant deterioration of air quality in attainment areas. The PSD requirements placed limits on the “increment” of clean air that could be used by industrial projects. Allowable increments have been established for both Class I (pristine) and Class II (non-pristine) areas. Most Class I areas are National Parks or Wildernesses designated in the 1977 Amendments. Federal land managers are responsible for ensuring that major new sources of air pollution permitted under PSD will not adversely affect the air quality related values of Class I areas.

Air pollutants of primary concern on the National Forests include PM_{10}, O_3, SO_2, NO_x and mercury (Hg). PM_{10} is the primary pollutant that can be generated on National Forests through prescribed fire or wildfire. It can affect human health, visibility, and temporarily affect road safety by reducing visibility along travelways. O_3, SO_2, NO_x and Hg tend to be generated in urban and industrial areas but can be transported to the Forest where they can affect sensitive resources such as vegetation, lakes and wildlife. NO_x is a precursor of O_3 that can cause foliar injury and reduce the growth of sensitive vegetation such as white ash, trembling aspen, and black cherry. SO_2 concentrations can also affect sensitive vegetation such as aspen, yellow birch, white pine, and jack pine. SO_2 can be converted to sulfuric acid in the atmosphere and deposited as acid precipitation that can acidify lakes with little or no acid neutralizing capacity. Hg deposition can affect aquatic ecosystems and wildlife through bioaccumulation in the food web. There are concerns about human consumption of fish with high mercury levels as well as the effects on piscivorous wildlife such as loons and otters.

Air quality within the Chequamegon-Nicolet National Forests is generally good. All Forest areas attain the Clean Air Act standards for the six criteria pollutants described above. With a few exceptions, this results in clean air from the standpoint of human health and visibility. However, air pollutants such as acid precipitation, Hg deposition, and ozone can affect natural resources.

Precipitation pH and SO_4 deposition currently have a strong southeast to northwest gradient across Wisconsin (NADP 2001). Precipitation pH ranges from 4.7 in southeastern Wisconsin to 5.3 in the northwest corner of the state while SO_4 deposition ranges from 16 kg/ha/yr in the southeast to 9 kg/ha/yr in the northwest.

Precipitation pH increased and SO_4 deposition decreased across the Forests during the last two decades. From 1980 to 2001, average annual precipitation pH increased from 4.65 to 5.0 at Trout Lake, Wisconsin and 4.85 to 5.15 at Spooner, Wisconsin. During the same period, SO_4 deposition declined at both sites from about 14 to 8 kg/ha/yr (although the rate of decline leveled off during the last four years of the study and actually increased slightly at the Spooner site).

Hg is a concern in the aquatic environment because it bio-accumulates in fish causing toxicity concerns for humans and wildlife. Atmospheric deposition of Hg is considered the dominant source of Hg in lakes. Current rates of atmospheric deposition of Hg are sufficient to cause fish consumption advisories for many lakes in northern Wisconsin.

Ozone data from Sommerset and Lake Dubay/Polk County, Wisconsin were analyzed for impacts to vegetation in Rainbow Lake Wilderness (Krupa 1994). The results of this analysis are probably applicable to both Forests. Various statistics indicated the area could be classified “clean” and ozone levels appeared to be sufficiently low to protect sensitive vegetation from adverse impacts.

Rainbow Lake Wilderness is a Class I air quality area. The Forest Service has an affirmative responsibility to protect Air Quality Related Values (AQRVs) of the Wilderness from major new sources of air pollution. AQRVs are important Wilderness resource characteristics that could be affected by air pollution. The AQRVs for Rainbow Lake Wilderness are water, vegetation, wildlife, scenic beauty, and odor. Several very soft water seepage lakes (Bufo, Anderson, Reynard, and Wishbone) are the most sensitive resources with respect to air pollution. These lakes have acid neutralizing capacities ranging from –9 to 48 ueq/l over the past 18 years making them very sensitive to acid deposition. All four lakes had acid neutralizing capacities less than 25 ueq/l the last few years and Bufo Lake was below zero twice. The Forests contain about 30 soft water seepage lakes sensitive to acid deposition.

Current Management Direction

Ecosystem Vegetative Composition, Structure, and Function

A variety of sources form the legal and administrative framework for current management of vegetative composition, structure, and function. The Endangered Species Act (1973) protects individual species and the ecosystems they depend on. The Wilderness Act (1964) indirectly promotes biological diversity through habitat conservation and addresses compositional, structural, and functional components of biological diversity.

The National Forest Management Act of 1976 (NFMA) states “forest plans must provide for the diversity of plant and animal communities based on the suitability and capability

of the specific land area…and provide…for steps to be taken to preserve the diversity of tree species similar to that existing in the region controlled by the plan" [Section 6(g)(3)(B)]. NFMA provides further guidance for the purpose and intent of forest plans:

- 36 CFR 219.26 states, "Forest planning shall provide for diversity of plant and animal communities and tree species consistent with the overall multiple-use objectives of the planning area."
- 36 CFR 219.27(g) states management prescriptions, "where appropriate and to the extent practicable, shall preserve and enhance the diversity of plant and animal communities."
- 36 CFR 219.19 requires the Forest Service to identify and prevent the destruction or adverse modification of habitat determined to be critical for threatened and endangered species. It states that fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired Non-native vertebrate species. Viable populations are defined as those with sufficient numbers and distribution of reproductive individuals to ensure their continued existence in the planning area.

Forest Service Manual direction requires that "A forest plan must address biological diversity through consideration of the distribution and abundance of plant and animal species, and communities to meet overall multiple-use objectives" (FSM 2622.01). The Manual further states "Management of habitat provides for the maintenance of viable populations of existing native and desired Non-native wildlife, fish, and plant species, generally well-distributed throughout their current geographic range" [FSM 2622.01(2)].

The Chief of the Forest Service issued a statement in 1992 committing the Forest Service to ecosystem management, an ecological approach to managing national forests and grasslands for multiple uses.

The 1986 Land and Resource Management Plans (Forest Plans) for the Chequamegon and Nicolet National Forests have no specific goal statements for vegetative composition, structure, and function. These issues are addressed through other resource goals. For instance the Chequamegon Plan speaks to the issue through a wildlife goal to, "Provide the greatest diversity Forest wide for purposes of protecting and maintaining a variety of habitats for all plants and more than 300 species of animals, for purposes of maintaining healthy gene pools, for purposes of controlling insect and disease infestations, and for purposes of meeting a variety of other resource management objectives" (Chequamegon LRMP, IV-1).

The Nicolet Plan follows the same approach through a wildlife-related goal to, "Provide for diversity of plant and animal communities by working toward the desired future vegetative composition, age class distribution, and spatial distribution set forth in the plan" (Nicolet LRMP, 21).

Forestwide Standards and Guidelines of the 1986 Chequamegon and Nicolet Plans do not directly address vegetative structure and function, except through wildlife needs. There are Standards and Guidelines in the Chequamegon Plan for wildlife habitat improvement and maintenance. In addition, the Chequamegon Plan identifies management Standards and Guidelines for wetlands, seeps and ponds, dead and down logs, beaver management, small openings maintenance, nesting structures, deer yards, snags and den trees, old growth, forage and cover, and grouse drumming sites.

The Nicolet Plan identifies management Standards and Guidelines for permanent openings, non-forested wetlands, impoundments, woodland ponds, riparian transition zones, old growth, reserve trees, upland game bird areas, deeryards, hunter walking trails,

and artificial nest/den structures. Directly or indirectly, these Standards and Guidelines affect vegetative composition, structure, and function.

Non-native Invasive Species

Federal Laws addressing aspects of NNIS management relevant to the Forest Service include the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. 4321 et seq.); Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended (16 U.S.C. 4701 et seq.); Lacey Act, as amended (18 U.S.C. 42); Federal Plant Pest Act (7 U.S.C. 150aa et seq.); Federal Noxious Weed Act of 1974, as amended (7 U.S.C. 2801 et seq.); Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.); and other pertinent statutes. The Forest Service is charged with preventing the introduction of invasive species or providing for their control, as well as minimizing the economic, ecological, and human health impacts caused by invasive species. The National Environmental Policy Act (1969), implementing regulations (40 CFR 1500-1508), and the Forest Service Manual 1950 and 1909.15, govern environmental analysis and disclosure requirements.

Authority to manage NNIS stems from the Federal Noxious Weed Act of 1974, as amended (7 U.S.C. 2801 et seq.), and requires cooperation with State, local, and other federal agencies in the application and enforcement of all laws and regulations related to management and control of NNIS. 36 CFR 222.8 acknowledges the Forest Service's obligation to work cooperatively to identify NNIS problems and develop control programs.

Department of Agriculture Departmental Regulation 9500-10 (DR 9500-10) specifically establishes Integrated Pest Management (IPM) as the preferred approach to NNIS prevention, control, and eradication. Direction for management of NNIS in the Forest Service is provided by FSM 2080, Noxious Weed Management. The newest amendment, No. 2000-95-5, (effective November 29 1995), established a policy emphasizing the importance of integrating NNIS management in ecosystem analysis, assessment, and forest planning. The objectives are to use the IPM approach to control and contain the spread of NNIS on National Forest System lands, and from National Forest System lands to adjacent lands, through: 1) the prevention of introduction and establishment of NNIS infestations; 2) the containment and suppression of existing NNIS infestations; 3) formal and informal cooperation with State agencies, local landowners, weed control districts and boards, and other federal agencies in the management and control of NNIS; and 4) education and awareness of employees, users of National Forest System lands, adjacent landowners, and State agencies about NNIS threats to native plant communities and ecosystems.

In 2001, the Forest Service published the “Guide to Noxious Weed Prevention Practices”. The Guide describes NNIS prevention techniques for use on projects in all resource areas including two new NNIS prevention practices required by Forest Service policy: 1) equipment washing and 2) posting of weed-free feed orders where they exist (USDA Forest Service 2001c).

Additional NNIS management direction comes from President Clinton’s Executive Order 13112 (May 1999), as well as the USDA Forest Service’s strategy “Stemming the Invasive Tide: A Strategy for Noxious and Nonnative Invasive Plant Management.”

The 1986 Forest Plans for both the Chequamegon and Nicolet National Forests contain no direction on NNIS management. Inventorying and monitoring of NNIS began in 1997. In 2001 the CNNF began integrating NNIS management into project analysis through

design features, project mitigations, and planned monitoring. Currently, the Chequamegon-Nicolet National Forests do not have a formal NNIS strategy or plan of action.

Soils

Current management direction provided by the 1986 Forest Plans covers ground-disturbing activities that may change soil properties through compacting, rutting, eroding, displacing, burning and removing nutrients. Under the Plans, all proposed actions would be assessed for site-specific direct, indirect and cumulative effects in order to avoid long-term impairment of soil resources. National and Regional soil quality standards would be met.

The Plans also call for the application of forestwide Standards and Guidelines for soil resource management as well as proven design features and mitigation measures. Current ecological unit/soil inventory and interpretive information would also be utilized. Wisconsin Forestry Best Management Practices (BMP) for water quality would be applied along with monitoring information gathered from BMP implementation across all ownerships in Wisconsin. All treatment areas would be monitored during project implementation. Resource specialists would monitor selected forestwide activity areas annually. Improvements to design features, identified through monitoring, research, and long-term soil productivity studies, would be applied in future projects to maintain acceptable limits of change for measurable and observable soil properties.

Air Quality

The current Land and Resource Management Plans for the Chequamegon and Nicolet National Forests provide very limited direction regarding air quality. Neither plan has goals or objectives for air quality. Both plans have forestwide Standards and Guidelines that deal with related issues such as developing mitigation measures for practices that adversely affect air quality and cooperating with the Environmental Protection Agency and other regulatory agencies. The Chequamegon plan also addresses air quality under the prescription for Management Area (MA) 5 (Wilderness). Rainbow Lakes Wilderness is a Class I air quality area. The MA 5 prescription defines the Air Quality Related Values (AQRVs) for Rainbow Lake Wilderness, provides general direction regarding baseline monitoring of AQRV indicators, and provides direction if developments exceed the threshold level for one or more wilderness AQRVs. Although objectives do not exist for air quality, monitoring of the Rainbow Lake Wilderness AQRVs has occurred within the last two decades. These activities included monitoring of lake water quality, fish mercury levels, and a lichen survey. The Forests have also reviewed PSD permits for potential effects on the Class I air quality area.

Proposed Changes and Range of Changes

Ecosystem Vegetative Composition, Structure, and Function

Current management situation assessments and analyses conclude that there is a need for change in the composition, structure, and function of the Forests' terrestrial ecosystems (see Analysis of the Management Situation documents for Ecosystem Restoration, Landscape Pattern, and Ecosystem Restoration, and Old Growth for examples). All alternatives, except Alternative 1, increase mid- and late-successional forest habitat, restore rare or regionally under-represented terrestrial ecosystems such as natural

red/white pine forests, restore within-stand structural features such as canopy gaps and snags, and provide management direction (through MA allocation and standards and guidelines) that aims to protect species sensitive to deer herbivory such as eastern hemlock, white cedar, and numerous forest herbs. These changes are accomplished through Goals and Objectives, Standards and Guidelines, and Management Area prescriptions and allocations. Ecosystem representation and restoration changes are discussed in the Old Growth and Special Land Allocations sections of this chapter. Changes to terrestrial vegetation at a landscape scale, such as habitat connectivity, are discussed in the Landscape Pattern section.

Management Areas (MA) 1-4 vary in the featured dominant upland forest type. MA 1A, 1B, and 1C emphasize early successional aspen, MA 2A, 2B, and 2C emphasize uneven-aged northern hardwood forests, MA 3A and 3B emphasize even-aged northern hardwood forests, and MA 4A, 4B, and 4C emphasize pine forests. There is further variation within these groupings in terms of desired future forest type, age class composition, disturbance regime, and stand structure. This produces future vegetation composition, structure, and function that vary by alternative and are combined with other MA designations such as Wilderness, Semi-Primitive Non-Motorized (SPNM), and Wild & Scenic Rivers.

The SPECTRUM model was used to project the acres of major forest type in 100 years. One of the fundamental assumptions of the SPECTRUM model is that timber harvest is the only disturbance factor. In areas unsuitable for timber harvest such as Wilderness, wetlands, and Research Natural Areas, pioneer or early successional species such as aspen, paper birch, and jack pine are assumed to convert in 100 years to longer-lived forest types. This model does not account for natural disturbances such as wind, flooding, insects, and wildfire that establish or maintain early seral types. The SPECTRUM projections listed below underestimate early seral types (aspen, paper birch, and jack pine) and overestimate by an unknown amount long-lived types such as northern hardwoods and white pine in areas unsuited for timber production.

- Northern Hardwoods range from 45.2% of uplands in Alternative 1 to 53.5% in Alternative 3.
- Aspen ranges from 16.4% of upland acres in Alternative 3 to 23.6% of uplands in Alternative 1.
- Red pine ranges from 9.1% of uplands in Alternative 1 to 9.5% in Alternative 6.
- White pine ranges from 2.6% of uplands in Alternative 1 to 4.5% of uplands in Alternative 2.
- Jack pine ranges from 1.9% of uplands in Alternative 3 to 2.4% of uplands in Alternative 1.
- Balsam fir ranges from 2.5% of uplands in Alternative 7 to 5.9% of uplands in Alternative 1.
- Spruce ranges from 1.7% of uplands in Alternative 4 to 2% of uplands in Alternatives 3 and 5.
- Oak ranges from 4.0% of uplands in Alternative 1 to 5.9% of uplands in Alternative 3.
- Small openings range from 2.3% of uplands in Alternatives 7 and 4 to 3% in Alternative 1.
- Lowland opening, lowland conifer, and lowland hardwood acres do not vary by alternative.

- Management Areas 2B, 3B, 4B, and 4C, collectively referred to as Alternative Management Areas (AMA), were designed to restore key vegetative structure elements within a forest actively managed for timber products. Alternative 1 has no AMA acres. Alternatives 2-9 and the Selected Alternative have Forest AMA acres ranging from a low of 51,600 acres (3%) in Alternative 1 to a high of 553,000 acres (37%) in Alternative 3. In addition, the Moquah Barrens Area (MA 8C), which emphasizes the restoration of the globally imperiled pine barren ecosystem, is included in this AMA grouping (7,481 acres in Alternative 1 and 14,000 acres in all other alternatives).

Non-native Invasive Species

Alternatives 2-9 and the Selected Alternative propose new forest biological diversity objectives to annually treat roadside NNIS occurrences and to develop strategies to limit the spread of NNIS. Additionally, Alternatives 2-9 and the Selected Alternative also include Forestwide Standards and Guidelines specific to Non-native Invasive Species (Chapter 2 of the Forest Plan).

Air Quality

The proposed changes include the addition of a goal (Goal 1.6) for air quality.

Comparison of Current Conditions to Estimates of Natural Variation (Range of Natural Variability)

The General Assessment on the Historic Range of Variability (USDA Forest Service, 1998a) found in Appendix D of this document describes the estimated Range of Natural Variability (RNV) for natural disturbance regimes and forest composition, physical structure, and age structure.

The period beginning 3,000 years before present was selected as an appropriate time frame for RNV analysis because of the relatively stable climatic conditions and because today's forest species were present in the northern Wisconsin-western Upper Michigan area during that time (Davis et al. 1993; Webb et al. 1993). Pollen analysis indicates that this was a relatively stable climatic period. The overall rate of change in pollen types during the 8,000-year period ending prior to EuroAmerican Settlement was less than half the rate of change of the last century (Jacobson and Grimm 1986).

Clearcutting and slash burning during the early logging era, together with repeated cycles of cutting and fire suppression in more recent years, may have caused long-term changes in northern Wisconsin ecosystems outside the estimated Range of Natural Variability.

The pre-Euro American settlement landscape was likely a complex patch mosaic of differing forest types and ages. Today's smaller forest patches contain fewer species maintained at "truncated successional stages" (Pastor and Borschart 1990; Frelich and Lorimer 1991; Mladenoff and Pastor 1993).

The alteration, both compositionally and structurally, of northern hardwood and conifer forests has resulted in a "homogenization of stand ages and disturbance intervals" (Mladenoff and Pastor 1993) across the region. The intensive logging of the late 1800s and early 1900s greatly reduced or eliminated formerly dominant, mature forest types and habitats. Early-successional forest dominated by deciduous species subsequently claimed the sites. Great Lakes forests today have fewer species and are relatively uniform in age, composition, and structure -- a major departure from the northern hardwood-hemlock forests and pine forests which used to dominate the region. The northern hardwood-

hemlock forests of pre-EuroAmerican settlement times generally had larger, more long-lived tree species and longer natural disturbance intervals. Forests were dominated by older-growth northern hardwoods with aspen-birch types invading recently disturbed sites and jack pine, white and red pine persisting on droughty, fire dominated sites.

Frelich and Lorimer (1991) estimated that over 85% of the upper Great Lakes forests were in a mature or old growth stage at the time of European settlement. Current forest age-class distributions are significantly different from pre-European settlement forests (Frelich and Lorimer 1991).

In addition to age-class distribution, which is discussed in more detail in the *Research Natural Areas, Special Management Areas, and Old Growth Complexes: Comparison of Present to RNV* section of this chapter, other differences exist between current terrestrial vegetation conditions and RNV conditions. Schulte et al. (2002) examined Northern Forest historical composition and structure using U.S. Public Land Survey bearing-tree data collected in Wisconsin between 1832 and 1866. This data can be used to characterize vegetation patterns across broad spatial scales (Manies and Mladenoff 2000). They calculated the relative importance values and relative dominance values for land cover classes of Province 212 (see Figure 3-3, and Tables 3-11 and 3-12).

Figure 3-3. Province 212 (shaded area).

Table 3-11. Relative Importance Values for Major Land Cover Classes in Historical Vegetation Structure and Composition (Based on U.S. PLS bearing tree data collected 1832-1866, from Schulte et al 2002)

Land Cover Class	Relative Importance
Aspen	1.4
Aspen-White Pine	2.9
White Birch	2.6
Hemlock	6.9
Hemlock-Beech	1.8
Hemlock-Sugar Maple	5.9
Hemlock-White Pine	4.2
Hemlock-Yellow Birch	7
Sugar Maple	3.9
Sugar Maple-Elm-Ash-Basswood	4.8
Sugar Maple-White Pine	3.2
Yellow Birch	4.7
Yellow Birch-Sugar Maple	5.3
Beech	1.4
Tamarack-Hemlock-Yellow Birch-Sugar Maple	3.8
Red Pine-White Pine	4
Spruce-Tamarack-White Pine-White Birch	3.8
Jack Pine	2.9
Red Pine	3.8

Table 3-12. Relative Dominance Values for Major Land Cover Classes in Historical Vegetation Structure and Composition (Based on U.S. PLS bearing tree data collected 1832-1866)

Land Cover Class	Relative Dominance
Aspen	3.5
Cedar	4.1
Spruce-Tamarack-White Pine-White Birch	3.1
Hemlock	7.5
Hemlock-Sugar Maple	5.2
Hemlock-Yellow Birch	8.6
Sugar Maple	3.9
Bass-Sugar Maple-Yellow Birch-Elm	5.3
Yellow Birch	4.9
Yellow Birch-Sugar Maple	6.2
Tamarack-Hemlock-Yellow Birch-Sugar Maple	2.9
Jack Pine	1.4
Red Pine	3.6
Red Pine-White Pine	3.9

Major changes of note include the following:

- Eastern hemlock and yellow birch, among the dominant trees in pre-Euro American settlement forests, are now relatively uncommon. Hemlock makes up 2% of trees in the maple-basswood forest type and yellow birch 2.4% (based on FIA data). Both are considered species of viability concern on the Forest. The decline of hemlock forest has had negative effects on bird populations associated with long-lived conifers. Elimination of hemlock has led to reduced numbers in several local bird species, including the black-throated green warbler, blackburnian warbler, and northern parula warbler (Howe and Mossman 1995), which demonstrated a declining trend in Wisconsin since 1966 (Robbins 1997).
- Pine and hemlock no longer dominate regionally, and more prevalent even-aged aspen stands lack the conifer component typical of naturally developed stands. In the Sylvania Wilderness Area, an area largely untouched in the cutover, large hemlock patches form the background or matrix of the landscape, a condition not found in the adjacent landscape (Mladenoff et al. 1993). White pine is much less common today compared with RNV conditions. Schulte et al. (2002) suggests that white pine was once 18% (relative dominance) and 11% (relative importance) of the forested area in Province 212. White pine represents 1% of Lake States timberland (Spencer et al. 1992). It decreased by 17% between 1983 and 1996 as a forest type, although white pine is increasing as understory in many forests.
- Pine plantations largely replaced Pine Barrens. In other cases, Pine Barrens successionally advanced out of the barrens condition due to fire suppression (WDNR 1995). Decline of Pine Barrens caused species viability problems for several savanna-associated fauna, such as sharp-tailed grouse (Temple 1989) and upland sandpiper (Robbins 1997), both Regional Forester Sensitive Species.
- The boreal forest has been reduced due to conversion to other forest types.
- Historically, northern white cedar was a common forest type and species. Today, white cedar has declined substantially. For example, 1.5% of the Forests are cedar (7% if mixed swamp conifer is included). Cedar continues to decline; acreage decreased 16% between 1983 and 1996 (Schmidt 1997, using data for Northeast, Northwest, and Central FIA Units).
- Natural red and mixed red/white pine forests were common on dry, sandy portions of the Forests. Aspen/white birch/oak/maple forests have largely replaced fire-origin white/red pine forests. Those that remain are in need of low-intensity fires that discourage fir and hazel, and maintain a relatively open understory. Red pine acreage increased by 26% between 1983 and 1996 due to planting.
- Aspen was “a minor and temporary constituent of wind-throws and other disturbed sites in the pre-settlement forest…due to its relatively shade-intolerant nature” (Whitney 1987). Summarizing other work, Frelich and Lorimer (1991) stated, “trees of all pioneer species typically made up less than or equal to 5% of the pre-settlement northern hardwood forest.” Schulte et al. (2002) concludes that aspen was between 3.5% (based on dominance values) and 1.4% (based on relative importance values) of the forested area in Province 212. The aspen type currently occupies a much larger landscape percentage, comprising 23% of the Forest (30% of uplands), and 17% of all Northern Wisconsin lands, according to Forest Inventory and Analysis (FIA measurements made in 1996).
- Many northern hardwood systems lack well-developed shrub layers, particularly composed of Canada yew. This is mostly true of young, even-aged forests and those

heavily browsed by deer (WDNR 2002a). Many wildlife species rely on this Forest layer for nesting, foraging, or cover.

- Pole-sized northern hardwoods lack elements of stand structure common to northern hardwoods stands in the past. Even-aged hardwoods lack well-developed vertical structure, an important bird habitat element. Howe and Mossman (1995) found that managed even-aged hardwoods had significantly lower bird densities and species diversity compared to managed uneven-aged hardwoods, old-growth hardwoods, and hemlock types.
- Today's forests are younger on average. Young forests lack structural diversity, including coarse woody debris, tip-up mounds, regeneration sites, cavities, and suitable nest trees for woodland raptors. Additionally, these forests lack the large, dying trees that cause small canopy gaps, important habitat for many birds such as the black-throated blue warbler.
- Large, old trees are relatively rare today, especially super-canopy conifers. Frelich and Lorimer (1991) estimate that over 85% of the upper Great Lakes forests were in a mature or old growth stage at the time of Euro American settlement. Forest age-class distributions are now significantly different from pre-European settlement forests (Frelich and Lorimer 1991).
- Thirty-eight percent of Forest upland acres are early seral forest type (aspen, balsam fir, paper birch, and jack pine). A high proportion of early-successional forest type landscape provides large amounts of browse, benefiting white-tailed deer. Historically, Northern Wisconsin white-tailed deer populations range from five to 16 deer per square mile (Dahlberg and Guettinger 1956; Habeck and Curtis 1959; McCaffery 1995). Presently, the Forests support over-winter deer densities averaging 23 deer per square mile (WDNR Adjusted Sex-Age-Kill estimate averaged during 1992-2001). Deer are profoundly affecting current and future composition and structure of the Northern Forest. *Wisconsin Deer Management for 2000 and Beyond* (Wisconsin Conservation Congress 2000) concludes, "Research projects have repeatedly documented that high herd densities damage natural, agricultural, and urban vegetation..."
- As a result of fire suppression and human-created changes in the composition and structure of the landscape, modern fire rotations are an order of magnitude longer than historical rotations (Cleland et al., *unpublished*). Surface fires were common in pine forests and pine-hardwoods in the pre-EuroAmerican period, but stand-replacing fires occurred every few hundred years.
- Wind was the dominant natural disturbance across the Forest, and was the primary form of disturbance on about 65% of the Forest. Wind disturbance caused mostly small gaps less than a tenth of an acre, and affected 0.57-0.63% of northern hardwood-hemlock forest annually (Frelich and Lorimer 1991). Larger wind disturbances such as blowdowns were rare – affecting 0.07% of the hemlock-northern hardwood forests of northern Wisconsin each year (Canham and Loucks 1984). Today, small-scale gap-phase disturbances resulting from fine-scale wind disturbance is lacking in second-growth northern hardwood forests. These trees, younger than historic forests, lack the structural characteristics that would make them susceptible to windthrow (WDNR 2002). A number of massive blowdowns occurred in Wisconsin and Minnesota in the last 25 years. These events were larger in magnitude than those historically observed (Frelich 2002). Some speculate that climate change is increasing thunderstorm size and severity in the U.S (Frelich 2002).
- Precipitation pH appears to be about 0.15-0.30 pH units below its natural level assuming natural (without air pollution) precipitation has a pH of about 5.3. Hg

deposition and ozone appear to be somewhat above their natural range and particulate matter is likely within the range of natural variation.

The sum of these changes has placed some CNNF ecosystems outside their estimated Range of Natural Variability. The ability of these systems to reorganize and remain in a dynamic equilibrium is unknown.

Direct and Indirect Effects

Effects on Vegetation Composition from Management Area Allocations

Figures 3-4 through 3-12 illustrate how vegetation changes over time by alternative. Each major forest type was projected into the future at 10 years and 100 years using the SPECTRUM model. As noted in the Timber Production section, one of the assumptions of the SPECTRUM model is that (Wilderness, etc.) pioneer or early successional species such as aspen, paper birch, and jack pine completely convert in 100 years to other longer-lived forest types in areas unsuited for timber harvest. This model does not account for natural disturbances such as wind, flooding, insects, and wildfire, which can and do result in the establishment of early seral types. Therefore, these estimates underestimate early seral types (aspen, paper birch, and jack pine) and overestimate by an unknown amount long-lived types such as northern hardwoods and white pine in areas unsuited for timber production.

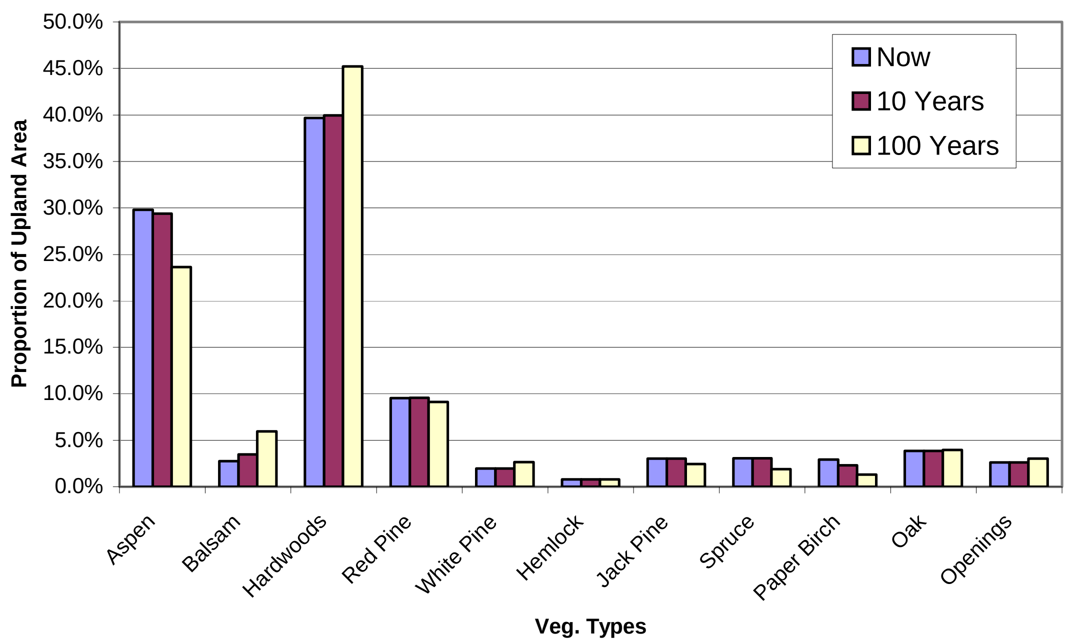

Figure 3-4. Alternative 1: Vegetation Change Over Time

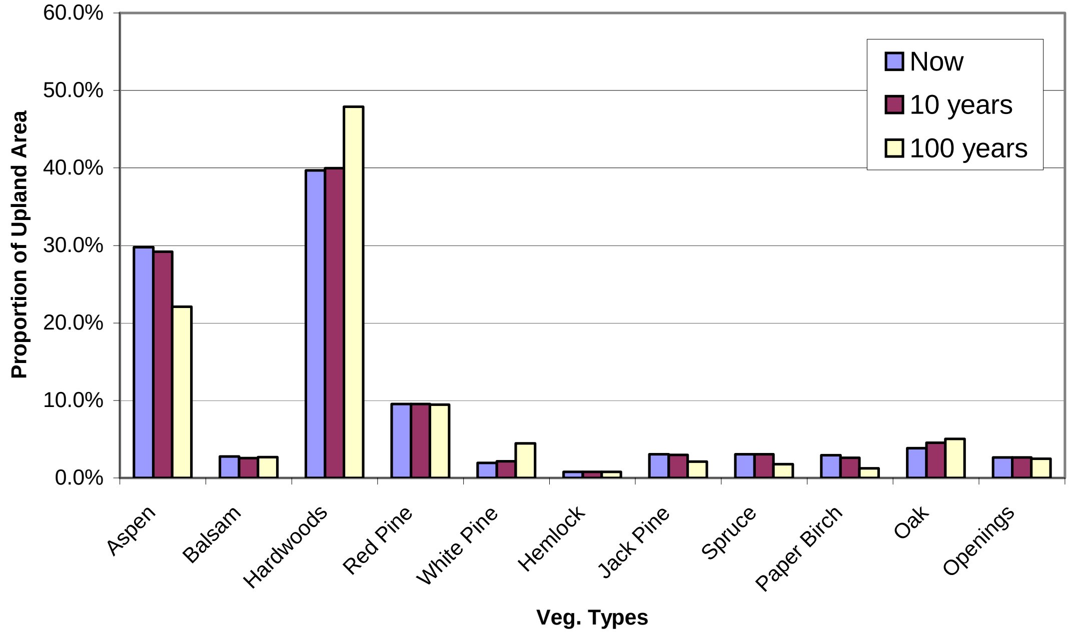

Figure 3-5. Alternative 2: Vegetation Change Over Time

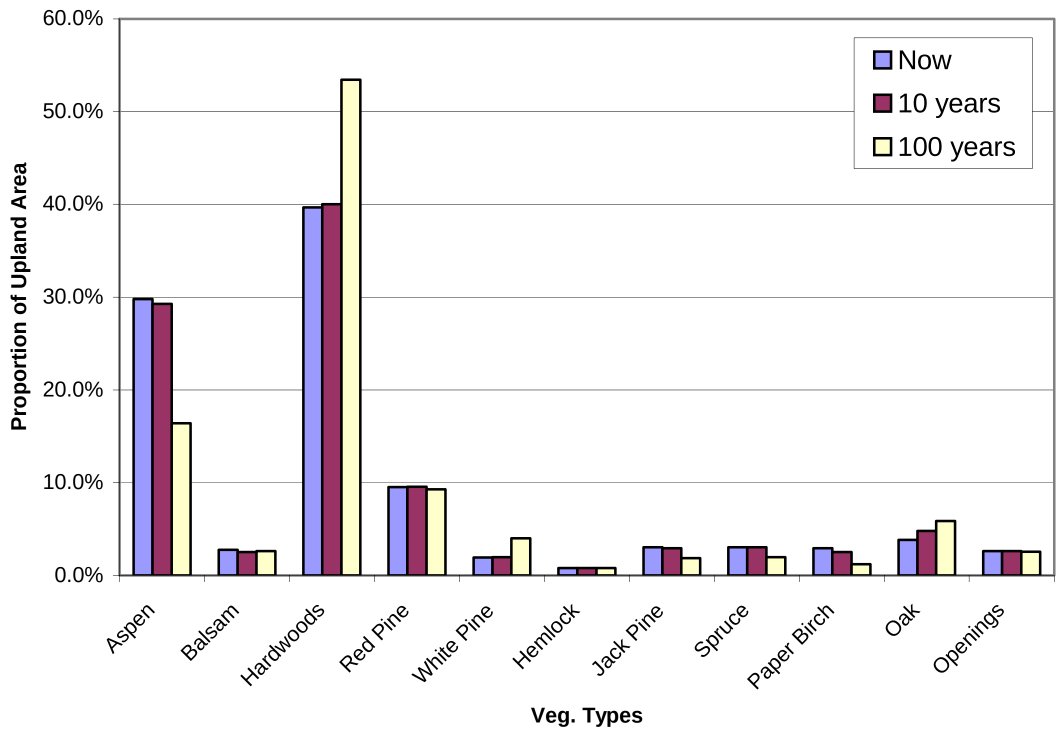

Figure 3-6. Alternative 3: Vegetation Change Over Time

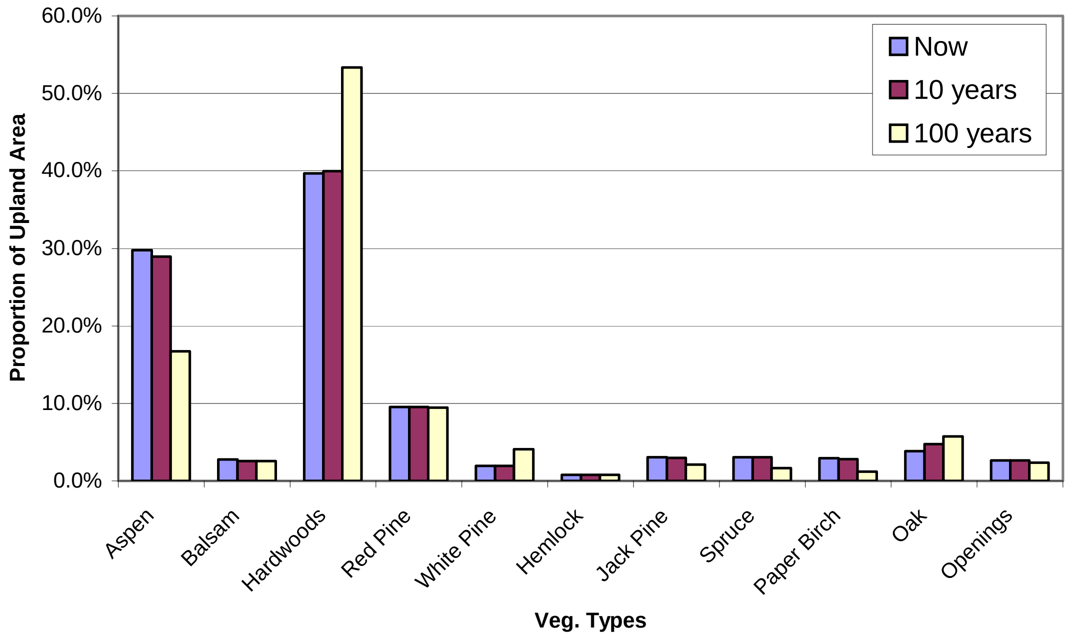

Figure 3-7. Alternative 4: Vegetation Change Over Time

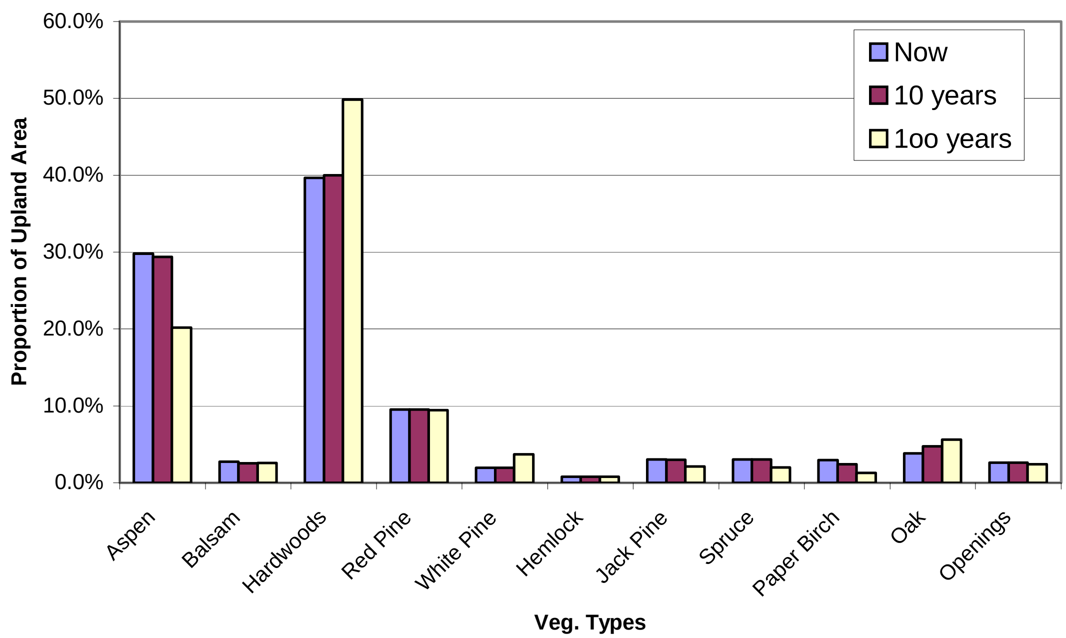

Figure 3-8. Alternative 5: Vegetation Change Over Time

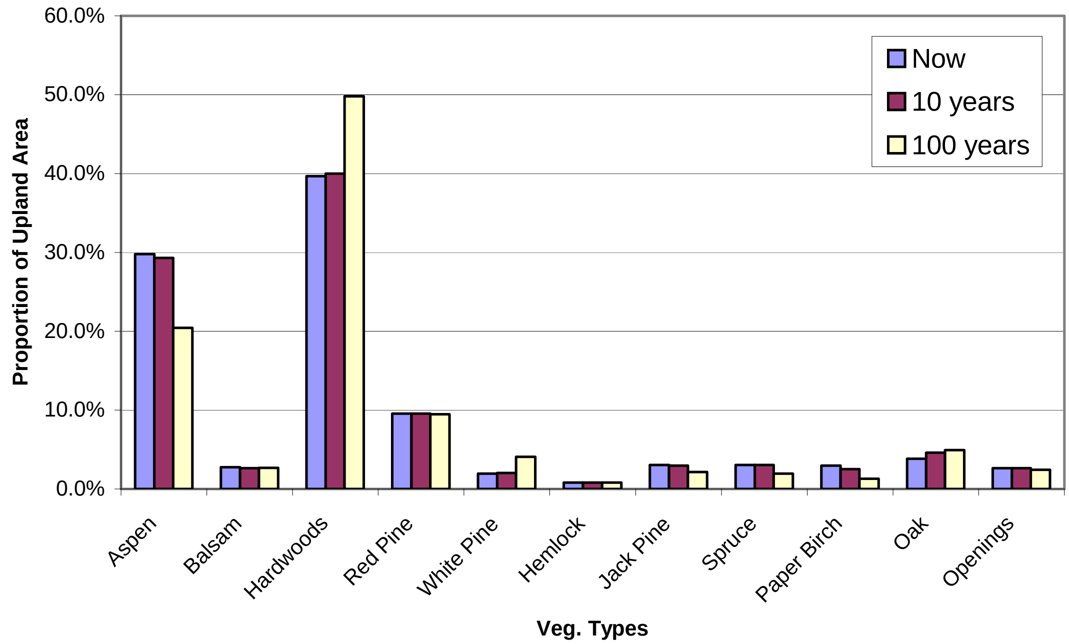

Figure 3-9. Alternative 6: Vegetation Change Over Time

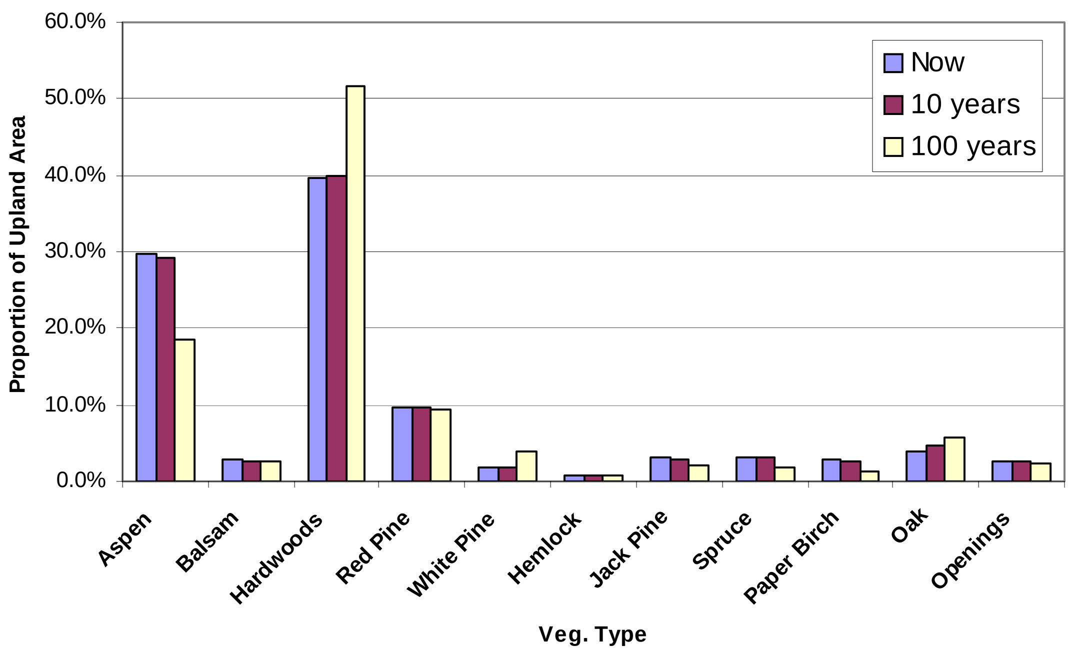

Figure 3-10. Alternative 7: Vegetation Change Over Time

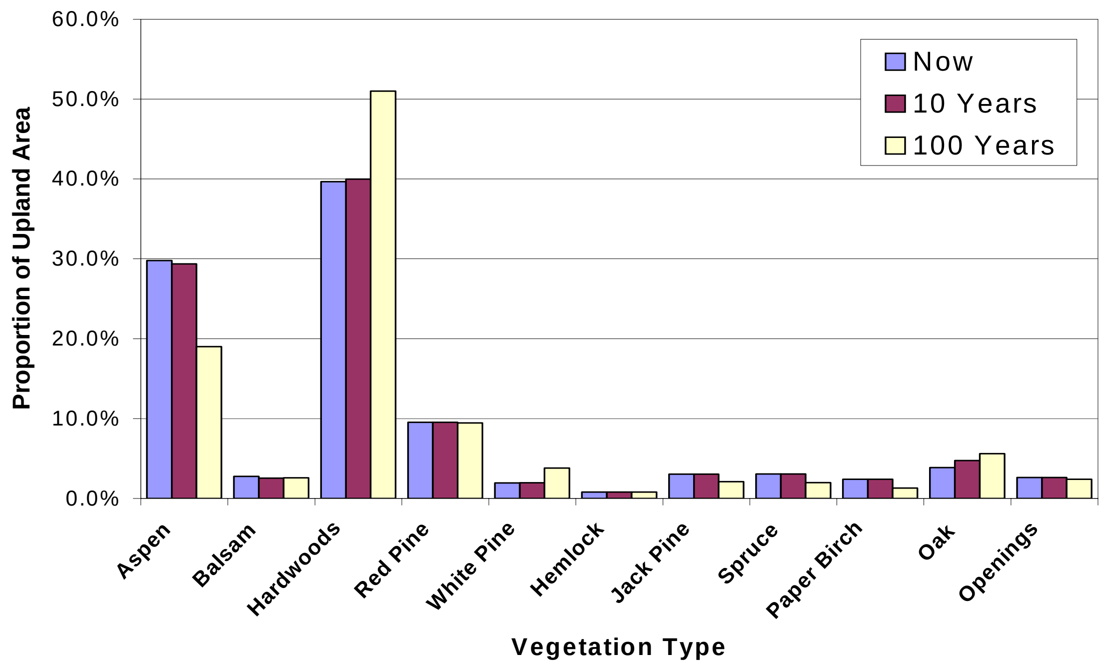

Figure 3-11. Alternative 9: Vegetation Change Over Time

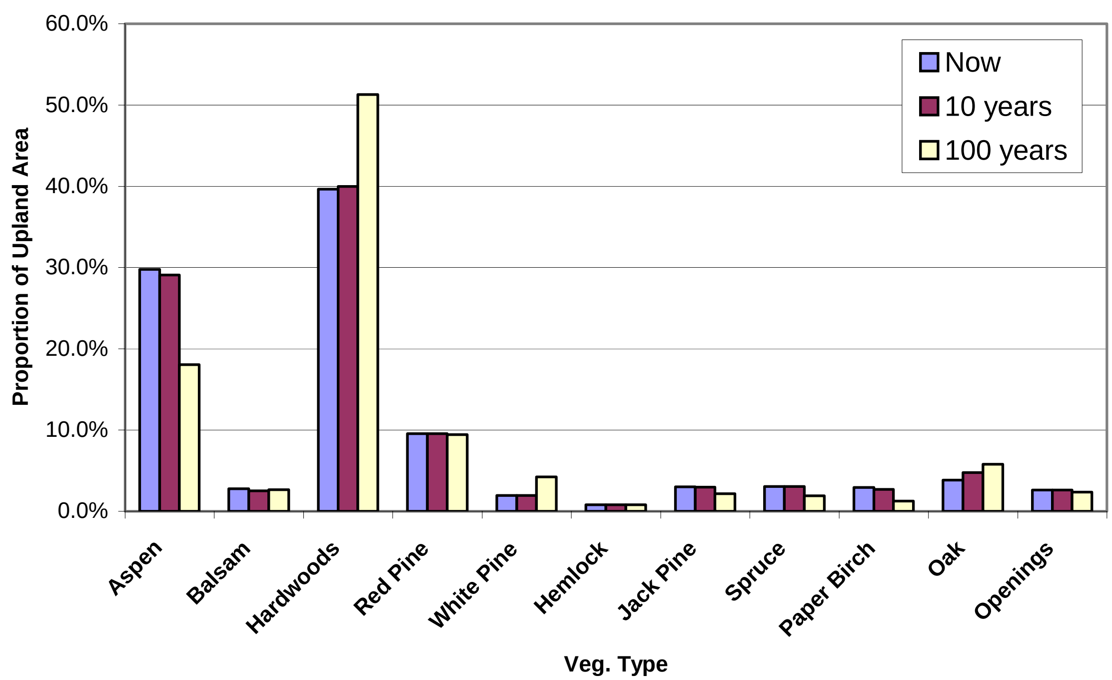

Figure 3-12. Selected Alternative: Vegetation Change Over Time

Future Vegetative Condition

Comparing alternatives, only a few vegetation types vary noticeably in their percentage of uplands at the 100-year projection point. Other vegetation types showed only very small differences among alternatives (within 1%). The northern hardwood type currently occupies approximately 40% of the Forests' uplands. The 100-year projection for northern hardwood ranges from 45% of the Forests' uplands in Alternative 1 to 53% in Alternatives 3 and 4. There is an increase in northern hardwoods from present condition (40% of uplands) in all alternatives, with the greatest increase (13%) occurring in Alternatives 3 and 4 and the smallest increases in Alternatives 1 and 2 (5% and 8%, respectively). The 100-year projection for northern hardwood is 51% under the Selected Alternative. See Figure 3-13 for comparison of the alternatives.

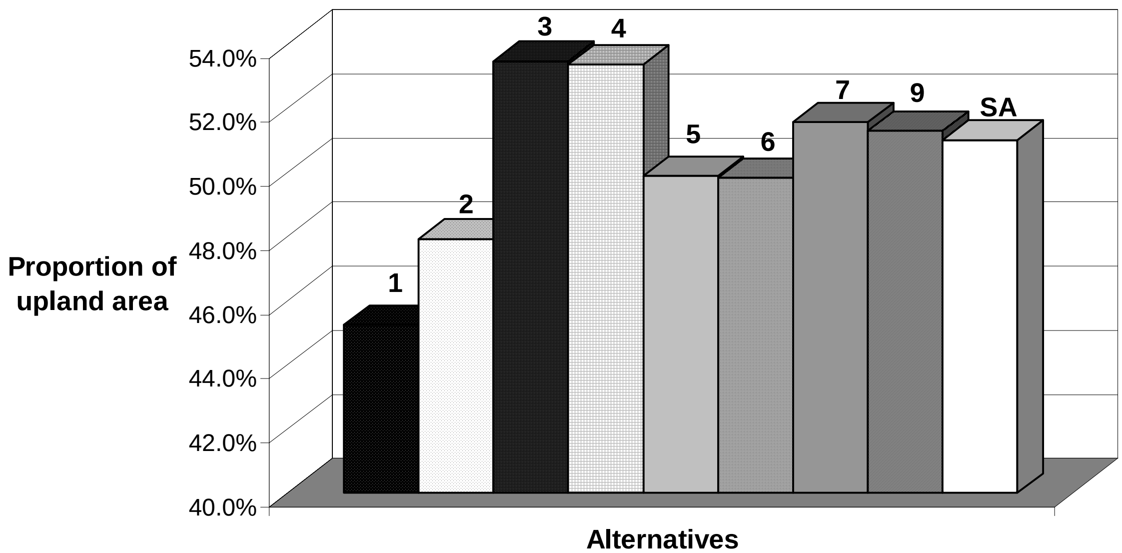

Figure 3-13. Projected Northern Hardwoods in 100 Years.

The 100-year projection of aspen type ranges from 16% of the Forests' uplands in Alternative 3 to 24% in Alternative 1 (Figure 3-14). Under the Selected Alternative, the 100-year projection of aspen type is 19% of the Forests' uplands. This represents a decrease in all alternatives from the current level of 30%, with the smallest decrease occurring in Alternatives 1 and 2 (6% and 8%, respectively) and the largest decreases in Alternatives 3 and 4 (14% and 13% respectively).

These projections are based on analysis conducted with the SPECTRUM model. It should be noted that the SPECTRUM model assumes that early-successional vegetation types such as aspen, paper birch, and jack pine that are located in areas not scheduled for timber harvest (Wilderness, for example) will completely convert in 100 years to longer-lived forest types. This model does not account for natural disturbances such as wind, flooding, disease, and wildfire, which can and do result in the establishment of aspen and

other early seral forest types. The model considers timber harvest as the only form of disturbance. Therefore, these projections underestimate early seral types (aspen, paper birch, and jack pine) and overestimate long-lived types such as northern hardwoods and white pine by the amount of natural disturbance that will occur in those areas of the Forest where timber management will not occur.

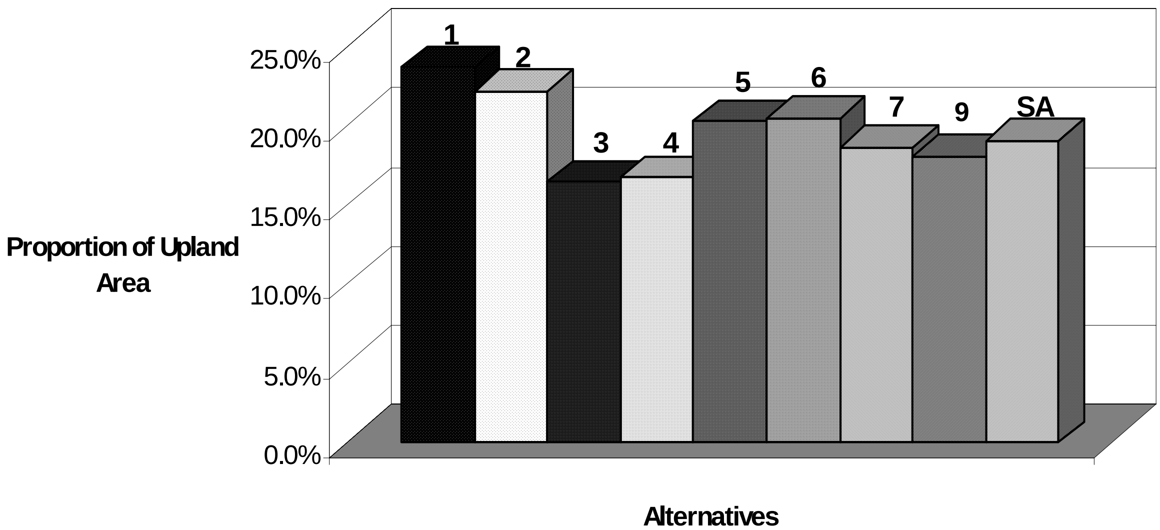

Figure 3-14. Projected Aspen in 100 yrs.

The 100-year projection of white pine-type is similar among Alternatives 2-9 and the Selected Alternative, ranging from approximately 3.7% in Alternative 5, to approximately 4.5% in Alternative 2. The projections indicate that the white pine type will occupy approximately 3.8% of upland acres in the Selected Alternative (Figure 3-15). Under Alternative 1 the white pine type is projected to occupy approximately 2.6% of upland area.

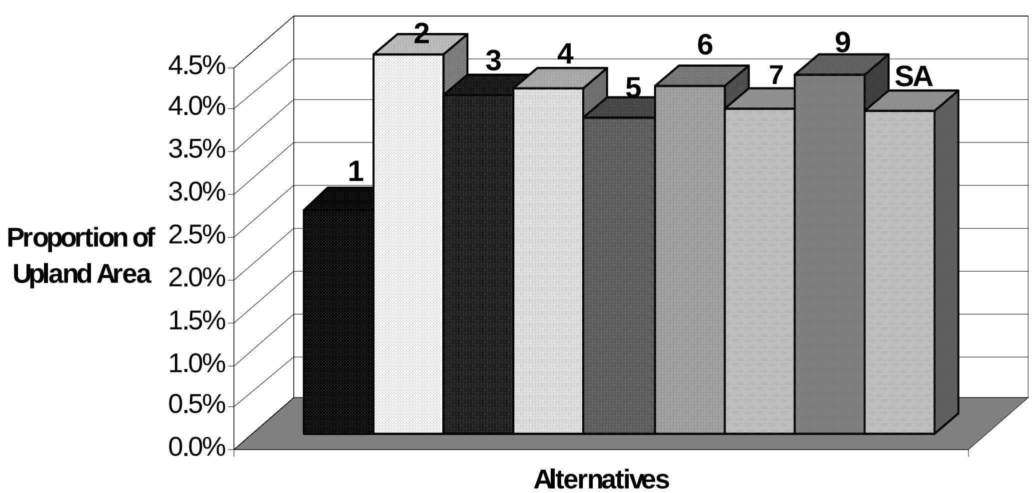

Figure 3-15. White Pine Projected at 100 yrs.

Balsam fir, in contrast, is projected to occupy more than twice the amount (6% of uplands) in Alternative 1 than any other alternative (Figure 3-16). This represents double the current amount of balsam fir in Alternative 1, and no change from current conditions in Alternatives 2-9 or the Selected Alternative.

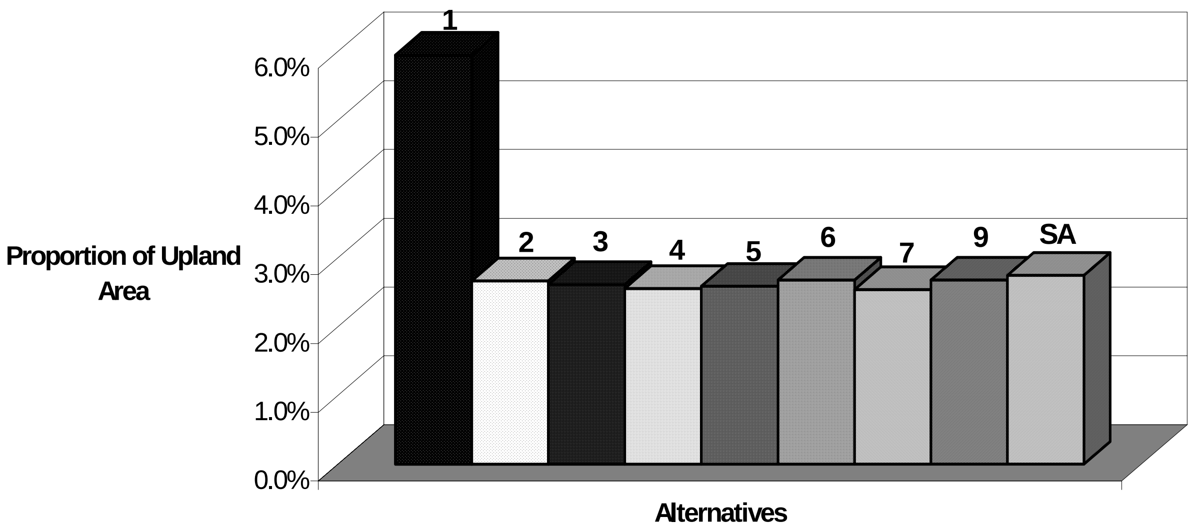

Figure 3-16. Balsam Fir Projected at 100 yrs.

For the four upland forest types (northern hardwoods, aspen, white pine, and balsam fir), which vary the most widely among alternatives in their 100-year vegetation composition projections, the direction of change for all alternatives is toward the estimated Range of Natural Variability (RNV). Alternatives 3 and 4 progress the most towards estimated RNV while Alternatives 1 and 2 progress the least.

Long-lived Conifer Component

The importance of long-lived conifer species such as white pine and hemlock is discussed in several plan revision documents including the Analyses of the Management Situation for Landscape Pattern and Ecosystem Restoration, and the General Assessments on Ecosystem Sustainability and Range of Natural Variation. Restoration or retention of a long-lived conifer component is emphasized in several Management Areas (MA) developed during plan revision, with the quantity of these MAs varying by alternative. Among MA 1 (early-successional forest emphasis) acres, MA 1B (aspen, mixed aspen-conifer, and conifer) emphasizes alternative silvicultural treatments, where feasible, to encourage conifer regeneration along with aspen. In addition, MA 1B emphasizes the retention or restoration of conifers, including the retention of conifers within aspen stands (see MA 1B management direction, Chapter 3 of 2004 Forest Plan). Figure 3-17 displays the proportion of MA 1 acres assigned to MA 1B, by alternative. Alternatives 9 and 3 have the highest proportion of MA 1B acres (31% and 30%, respectively), followed by Alternatives 6 and 2 (21% and 20%), followed by Alternatives 5, 7, and 4 and the Selected Alternative (10-12%), and Alternative 1 which has none.

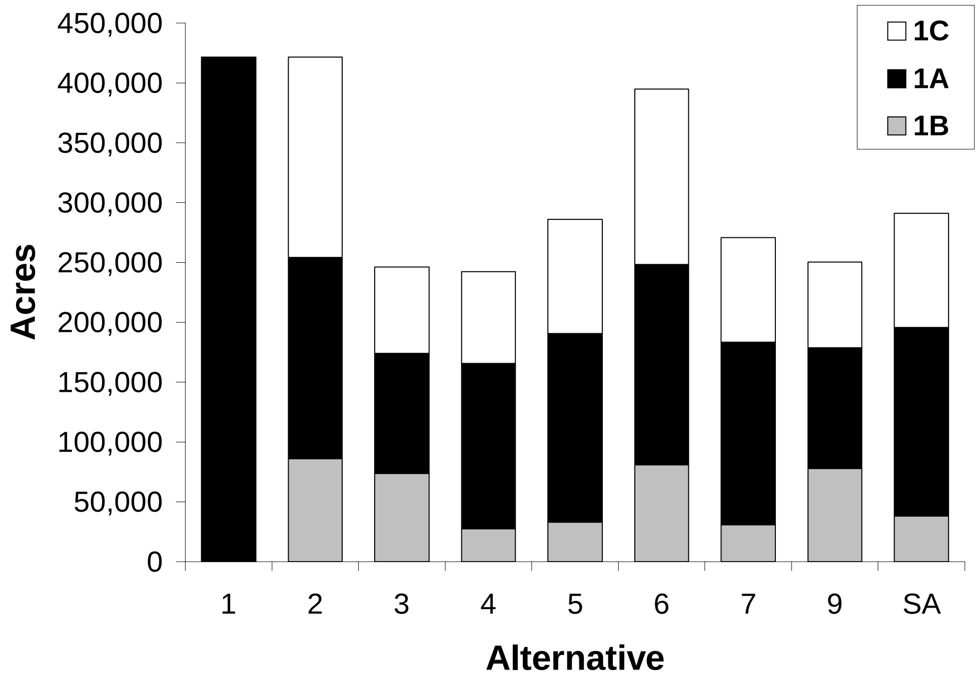

Figure 3-17. Composition breakdown of Management Area 1

Much of the existing long-lived conifer species (especially hemlock, white pine, and spruce) on the Forest occur within transition zones between uplands and adjacent lowlands. Several MAs (1B, 2A, 2B, 3B, and 4B) have a specific guideline aimed at protecting or enhancing existing conifer-dominated transition zones. These management areas emphasize retention of long-lived conifers (and hardwoods) as reserve trees within aspen clearcuts. The Selected Alternative has 463,000 acres—or 31% of the Forest—of these Management Areas. This is an increase of 57,000 acres from Alternative 5. Figure 3-18 displays the allocations to these Management Areas by alternative. For reference, the Forest land base is approximately 1,490,000 acres.

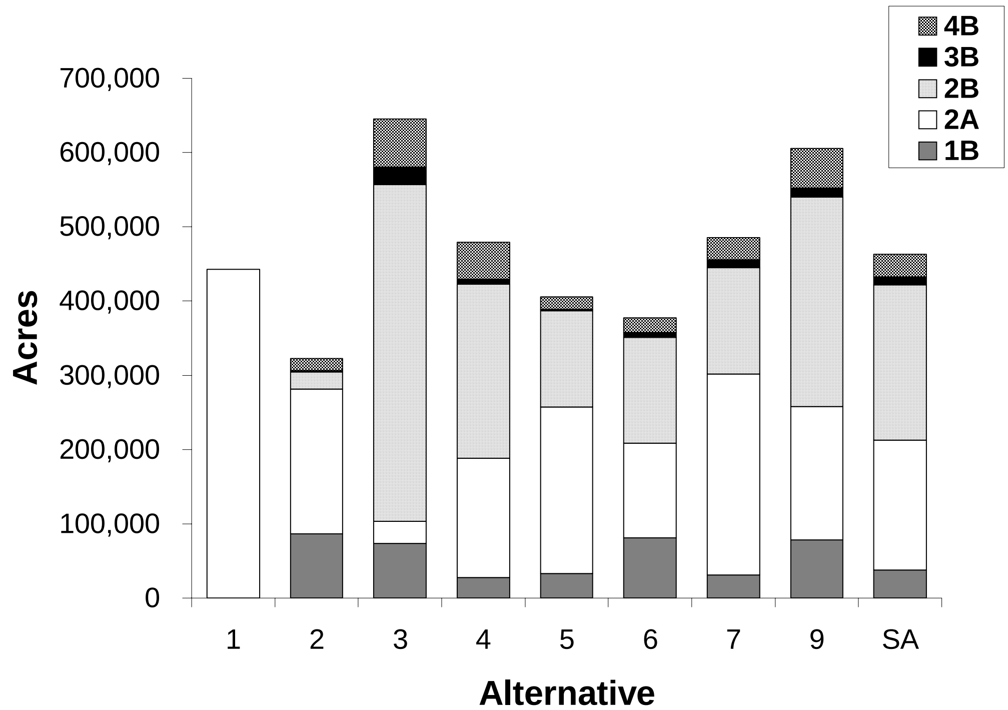

Figure 3-18. Allocations to MA 1B, 2A, 2B, 3B and 4B

All the MAs that permit commercial timber harvesting (MA 1-4) emphasize retaining long-lived conifers such as hemlock and white pine as part of the reserve live tree component during uneven-aged timber harvests.

A number of Forestwide Standards and Guidelines are directed at maintaining hemlock on the Forests. These guidelines apply to Alternatives 2-9 and the Selected Alternative. For example, hemlock trees will not be cut during harvest of northern hardwood stands, with minor exceptions (see Vegetation Management section, Chapter 3 of Forest Plan). Stands of hemlock are considered unsuited for timber production, except in cases where the need exists to benefit or maintain habitat for species of viability concern (see Vegetation Management section, Chapter 3 of Forest Plan).

Deer browsing is a major impediment to the successful establishment of hemlock (Rooney et al. 2000; Waller et al. 1996). Those MAs emphasizing uneven-aged, mature, or late-successional northern hardwood ecosystems are more likely to result in habitat and conditions favorable to hemlock regeneration by creating habitat and conditions that are unfavorable to deer. MAs that would result in favorable habitat conditions for hemlock include MA 2A, 2B, 2C, some 5, 5B, and 6A, as well as MAs 8D, 8E, 8F, and 8G (Wild, Scenic, and Recreational River Corridors, Research Natural Areas, Special Management Areas, and Old Growth & Natural Features Complexes). The alternatives are listed from most to least favorable in terms of hemlock regeneration according to the acreage allocated to the MAs listed above: 4, 3, 9, 7, 5, Selected Alternative, 6, 2, and 1. Although the Selected Alternative has 5,000 fewer acres of these management areas than Alternative 5, the number of acres allocated to management area 2B (northern hardwood

interior forest emphasis) has increased by 79,000 acres (a 61% increase). MA 2B benefits hemlock by emphasizing interior forest conditions and de-emphasizing the young, early seral forest and even-aged regeneration methods that provide favorable habitat for deer (discussed further in the Landscape Pattern Section). This increase is likely to result in overall improved conditions for hemlock regeneration compared with Alternative 5.

Overall, Alternatives 2-9 and the Selected Alternative improve the retention and restoration of long-lived conifer components through several Forestwide Standards and Guidelines. Based on the allocation of Management Areas that favor these species, Alternatives 3 and 9 are likely to benefit long-lived conifer, moving further towards long-lived conifer estimated RNV conditions. Alternatives 4 and 7 also move towards RNV conditions, although to a lesser degree. Alternatives 2, 5, 6 and the Selected Alternative have some beneficial effect, and Alternative 1 has the least significant benefit on long-lived conifer components.

Understory Vegetation

Understory vegetation within forested ecosystems plays an essential role in maintaining forest health, and is, in essence, the future of the forest. Nutrient cycling, tree seedling establishment, nesting habitat, and browse are important examples of forest understory functions. Northern hardwood forests are well known for their high diversity of vascular plants (Crow et al. 1994). Yet, there are growing concerns. More rare plants are associated with mesic northern hardwood forest than any other Forest ecosystem (see Appendix J). As Non-native or disturbance-adapted species increase (Crow et al. in press), native species decline (Rooney et al., unpublished manuscript). Seven of the nine bird species significantly decreasing on the Chequamegon are ground nesters (Lind et al. 2001). Figure 3-19 displays the proportion of northern hardwoods managed for timber production (suited hardwoods) by alternative. Alternative 4 has the fewest acres of northern hardwoods impacted by timber harvest, followed by 3, 7, 6, 5, 2, and 1 (highest). In the Selected Alternative, 71% of the Forests' northern hardwoods are classified as suited for timber production, which is the same as under Alternative 5.

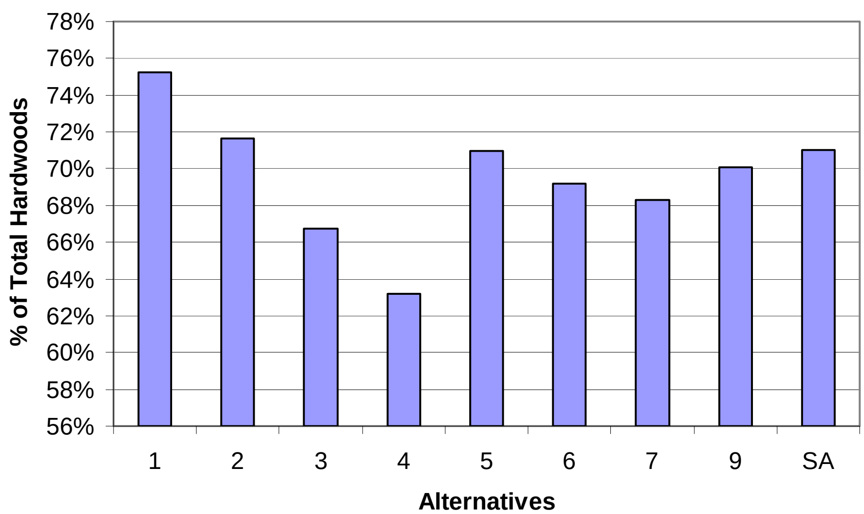

Figure 3-19. Proportion of Northern Hardwoods that are in the Suitable Timber Base

Alternatives 2-9 and the Selected Alternative all have the same Forestwide Standards and Guidelines addressing forest understory vegetation. A Forestwide Standard calls for maintaining ecosystem components, such as coarse woody debris, that contribute to re-colonization of disturbed areas (Timber Harvest Reserve Areas and Reserve Trees in Chapter 2 of the Forest Plan). A Forestwide Guideline requires reserve islands within even-aged (clear-cuts, over-story removal or other regeneration harvests) harvest units (Timber Harvest Reserve Areas and Reserve Trees Guidelines in Chapter 2 of the Forest Plan).

Management Area Standards and Guidelines vary in application by alternative due to differences in MA allocations. For example, Management Areas 2B, 3B, and 4B have a guideline establishing reserve areas or exclusions within timber sale areas to reduce impacts on ground flora and fauna and nesting birds (Biological Diversity guideline for MA 2B, 3B, and 4B, in Chapter 3 of Forest Plan). Figure 3-20 shows the amount of MA 2B, 3B, and 4B (combined), by alternative. Alternative 3 has the largest MA 2B/3B/4B allocation (over 35% of the Forest). Alternatives 4, 9 and the Selected Alternative have the next highest (17-23% of the Forest), and Alternatives 5, 6 and 7 are the lowest among the action alternatives (ranging from 10-12%). Alternative 1 has no acres allocated to these MAs.

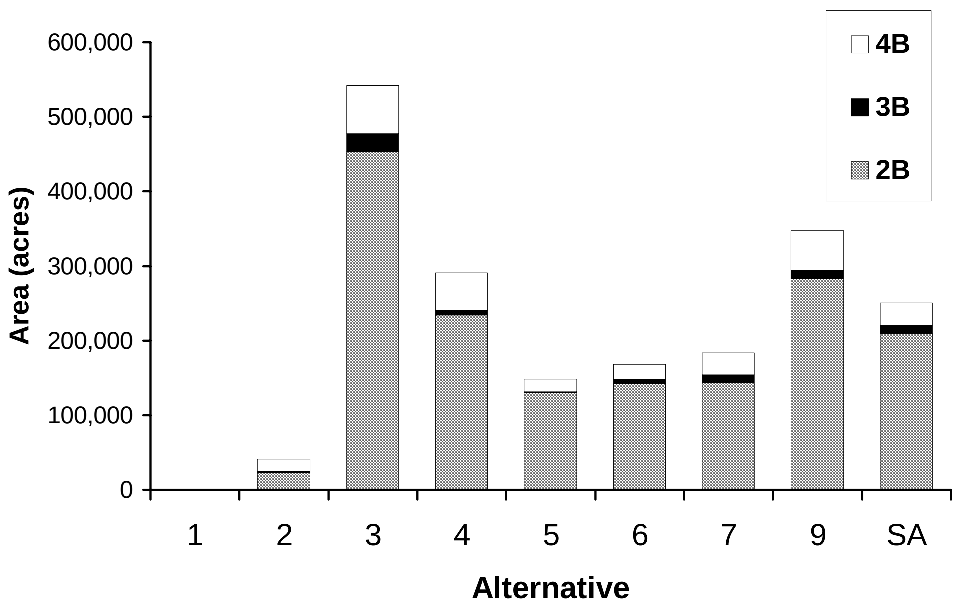

Figure 3-20. Acres of Management Areas 2B, 3B, 4B by Alternative

Summer logging can have harmful effects on understory vegetation (Buckley et al. in press), coarse woody debris (Lloyd 2002), and advanced tree regeneration (Groot 1996). Logging when the ground is frozen reduces impacts to understory vegetation. Timber harvesting in Northern Hardwood stands in MA 2B is restricted to frozen-ground conditions only. In other MAs, northern hardwoods may be cut during other times of the year, depending on soil conditions. Figure 3-21 compares suited northern hardwood percentages occurring in MA 2B, by alternative. Alternative 3 has by far the highest

proportion of MA 2B managed northern hardwoods (65%). Alternatives 9 and 4 have the next highest (42%, 39%). Alternatives 5, 6, and 7 are lower (20-23%). Alternatives 1 and 2 have the least (0-3%, respectively). The Selected Alternative increased the proportion of managed northern hardwood in MA 2B to 31%, an increase of 11% from Alternative 5.

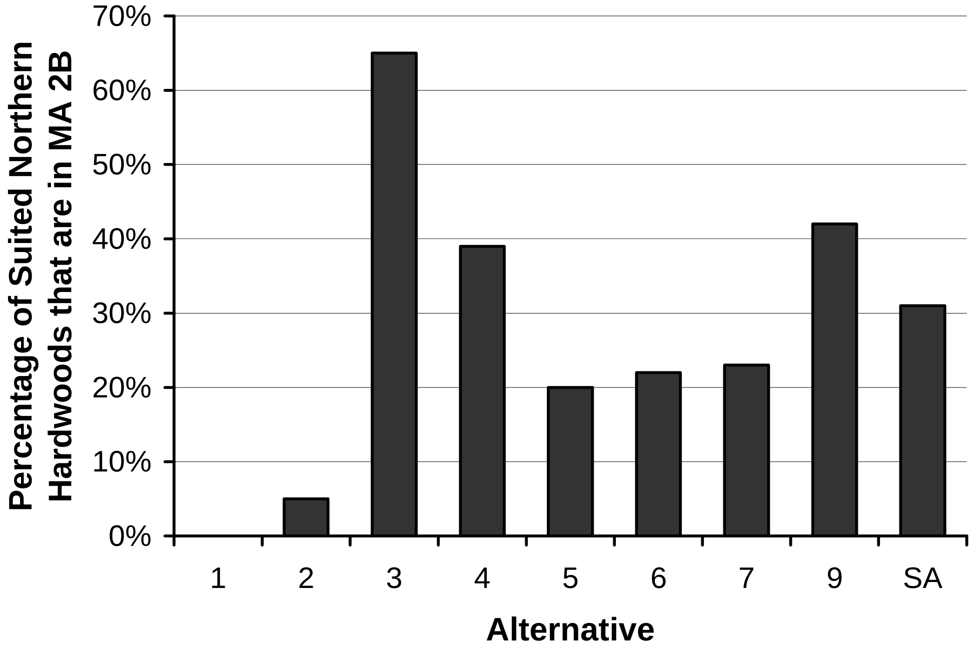

Figure 3-21. Percentage of the Forest's Suited Northern Hardwoods that are in MA 2B

The Species Viability Evaluation process in 2000 and 2002 highlighted concerns for several understory plant species associated with the Northern Hardwood ecosystem (SVE, 2002). Most of the plant species associated with this ecosystem that were considered by expert panelists require shade, continuous canopy, moist soils, high humidity and relatively cool temperatures. Light, along with habitat loss/fragmentation, was listed as a threat more often than any other factor. However, other species of viability concern such as yellow birch, butternut, and wood thrush require canopy gaps for regeneration or developing nesting habitat. Canopy-gap concerns for northern hardwood stands managed with an uneven-aged silvicultural system are addressed in Alternatives 2-9 and the Selected Alternative by creating canopy gaps of between 20-60 feet, while still maintaining a crown closure of at least 80% with initial thinning exceptions (Vegetation Management Guidelines, Chapter 2 of Forest Plan). Maintaining at least 80% canopy appears to retain continuous canopy conditions required by the majority of species considered.

However, northern hardwoods managed with an even-aged system eventually regenerate using a shelterwood harvest that maintains only 60% of the canopy, followed by removing the overstory within 5-10 years. Even-aged hardwood management varies by management area and alternative. MA 2C has the highest proportion of even-aged hardwood management, followed by MA 2A among the northern hardwood emphasis MAs. Management Area 2B features only uneven-aged northern hardwood management. Thus, while MA 2A, 2B and 2C all emphasize uneven-age management of Northern Hardwoods, compositional guidelines for some species (e.g. paper birch, oak) may lead to

some even-age management in these MAs. Figure 3-22 compares the relative amounts of these MAs by alternative. Alternative 1, which has MA 2C acres but no MA 2A or 2B, has the highest proportion of even-aged northern hardwood management. Alternative 2 has the second highest and Alternative 3 the lowest.

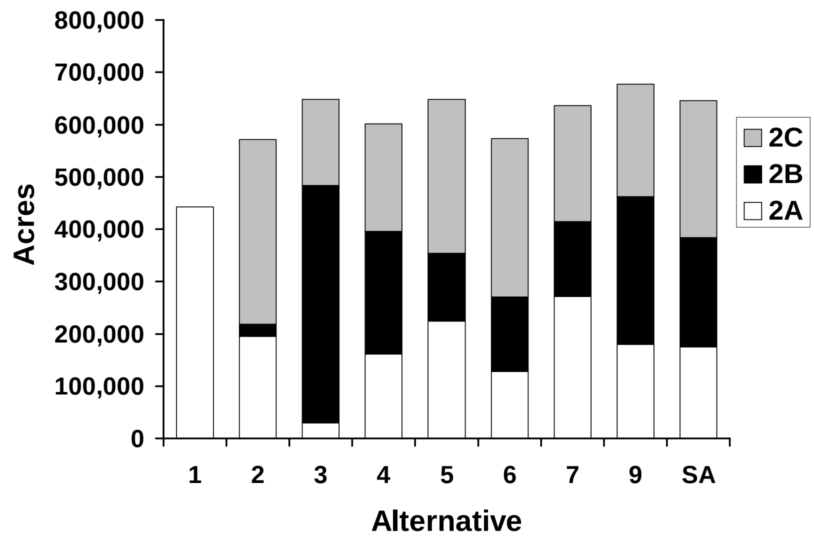

Figure 3-22. Breakdown of MA 2 (by A, B or C)

Even-aged northern hardwood management also occurs in other MAs, in particular, MA 3B and 3C where it is emphasized, depending on site and type conditions (Vegetation Management guidelines, Even-aged Management of Northern Hardwoods, Chapter 2 of Forest Plan).

Deer browsing is a major risk to forest understory vegetation (USDA FS 1998f, 2000a, 2000c). This topic is addressed in detail in the Landscape Pattern section of this chapter since the principle tool for addressing this issue in the Forest Plan is through management area allocations across the landscape.

Red and White Pine forest understories are more diverse in MA 4B compared with other red/white pine forests under different management area prescriptions where timber harvests occur. MA 4B emphasizes natural, rather than artificial, red and white pine forests where fire is part of regeneration and possibly maintenance practices. Figure 3-23 shows the proportion of suited pine occurring in MA 4B, by alternative. Alternative 1 has no MA 4B areas. Alternative 3 has the highest proportion of suited pine assigned to MA 4B (13%), followed by Alternatives 4 (11%), and 9 (10%). Alternatives 5, 6, and 7 all have 4% of suited pine in MA 4B. The Selected Alternative has 7% of the suited pine assigned to MA 4B, a 3% increase over Alternative 5, and the fourth highest among alternatives.

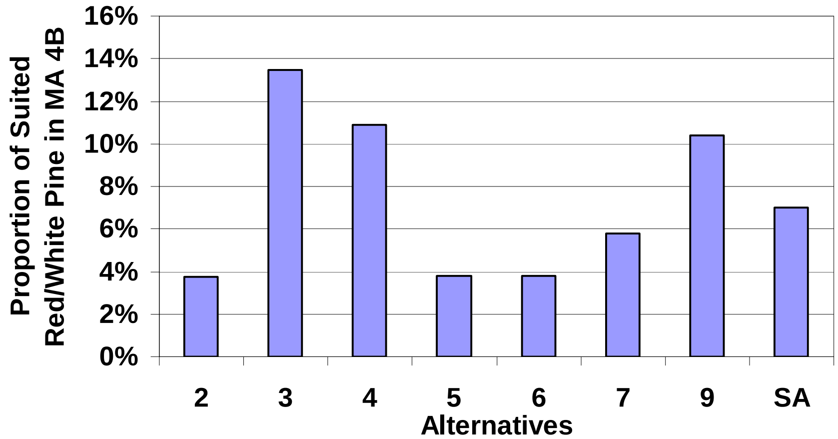

Figure 3-23. Proportion of Suited Red Pine and White Pine in MA 4B

Overall, Forestwide Standards and Guidelines will benefit understory vegetation in Alternatives 2-9 and the Selected Alternative. Based on acres allocated to MAs that provide additional protection to forest understory vegetation, a consistent pattern emerges with Alternative 3 providing the greatest beneficial effects. Alternatives 4 and 9 consistently rank near each other, and higher than the remaining alternatives. Alternatives 5, 6, and 7 also consistently rank near each other, lower than Alternatives 3, 4, and 9, but higher than Alternatives 1 and 2. Alternatives 1 and 2 consistently provide the fewest acres of favorable management conditions. The Selected Alternative falls within the mid-range of the alternatives.

Pine Barrens and Associated Habitats

Pine Barrens community is a globally imperiled (G2) ecosystem. A number of rare species are associated with this ecosystem including sharp-tailed grouse, upland sandpiper, and *Botrychium rugulosum*. This rare ecosystem once was well represented in the droughty, sandy areas of the Forests, particularly the Washburn District north of State Highway 2. Alternatives 2-9 and the Selected Alternative increase Pine Barrens restoration efforts (MA 8C). The largest of these restoration areas is the Moquah Barrens Area, which increases from 7,481 acres in Alternative 1 to 13,686 acres in Alternatives 2-9 and the Selected Alternative. Smaller "satellite" barrens have also been designated in portions of the northern Washburn District.

In addition to the Moquah Barrens and Satellite Barrens, MA 4C (Surrogate Pine Barrens) complements adjacent core barrens such as the Moquah Barrens by providing large, temporarily opened patches typical of the Pine Barrens ecosystem. These lands will eventually become forested with open-land conditions maintained through harvest on a regular site rotation.

In MA 4C jack pine clear-cuts are large and regeneration is natural, resulting in more compositionally diverse stands with more legacy trees, shrubs, forbs, and grasses. This has a positive effect on many species. For example, bird species diversity and abundance is positively correlated with shrub cover in jack pine clear-cuts (Niemuth 1995). Jack pine regeneration in other MAs may use natural or artificial methods and are typically less than 40 acres (see Vegetation Management Standard, chapter 2 of Forest Plan). Figure 3-24 compares the proportion of suited jack pine occurring in MA 4C, by

alternative. Alternative 1 has no MA 4C areas. Alternatives 3, 4, 5, 7, 9 and the Selected Alternative have 13% of jack pine in MA 4C; Alternatives 2 and 6 have 10%.

Based on acres allocated to restoring pine and surrogate barrens, the Selected Alternative has a similar, beneficial effect on pine barrens and associated habitats as Alternatives 2-9. All of these alternatives move in the direction of estimated RNV conditions for pine barrens on the Forest. Alternative 1 does not improve conditions for this ecosystem.

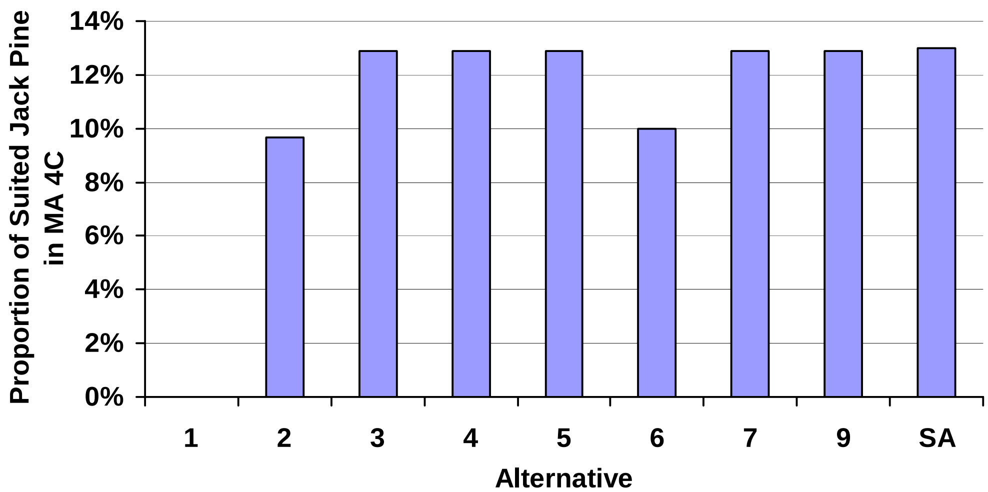

Figure 3-24. Proportion of Suited Jack Pine in MA 4C

Potential for Introduction of Non-native Invasive Species from Forest Management Activities

Some Non-native Invasive Species (NNIS) take advantage of disturbance situations to enter and invade native plant communities. Disturbance is usually in the form of vegetation removal, canopy opening, or soil exposure that result in conditions that allow the invader to be successful. Such species include grassland species like knapweeds and thistles. Other NNIS do not need disturbance but only require transportation to their preferred habitats. For example vehicle tires and logging or construction equipment are good transporters of garlic mustard, Eurasian water milfoil, and leafy spurge. Other species are actively planted in an area by humans, and then find their way into the forest. These include horticultural plants like purple loosestrife, buckthorns, and honeysuckles.

Essentially, management activities on the CNNF influence the amount of disturbance and opportunities for seed and vegetative material transportation, two elements that contribute to the spread of NNIS.

Timber management requires skid trails and decking sites to be created and roads to be built and maintained. Soil is disturbed and changes in vegetation structure and composition occur. All these activities create potential habitat for NNIS (Crow et al. 2002; Buckley et al., *in press*). Logging equipment and vehicles can carry and disperse the seeds of NNIS. Management activities like site preparation, which include prescribed burning and mechanical disturbance, also create habitat and provide opportunities for seed dispersal.

Table 3-13 shows the projected number of acres that may be harvested during the first decade of Forest Plan implementation. The number of potentially disturbed acres ranges from 18,000 acres (Alternatives 3 and 4), to 21,000 acres (Alternatives 1 and 2). The area of Forest potentially disturbed by prescribed burning or mechanical manipulation ranges from 9,000 acres (Alternatives 3 and 4), to 18,000 acres in Alternative 1 (Table 3-4). Under the Selected Alternative, approximately 20,000 acres would experience soil disturbance due to timber harvest and approximately 14,000 acres would experience mechanical manipulation or burning in the first decade.

Table 3-13. Measures of Timber Management Activities that could create potential NNIS habitat

Contributing Factor	Alt.1 C/N	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6	Alt.7	Alt.9	Sel. Alt.
Potential for soil resource disturbance: Projected number of Acres proposed for potential timber harvest in the first decade (in thousands of acres)	21	21	18	18	20	20	19	19	20
Area of potential soil disturbance due to prescribed burning or mechanical manipulation (in thousands of acres)	18	16	9	9	12	14	10	10	14

Roads provide habitat and opportunities for movement of NNIS plants (Forman and Alexander 1998; Trombulak and Frissell 1999). All aspects of road building, maintenance, and use create continual disturbance that mimics ideal habitat as well as spreads seeds and plant parts. Those alternatives that have greater densities of roads on the landscape will provide more potential habitat for NNIS. Alternative 4 has the largest area assigned an upper limit of 0 mi/mi^2 total road density: 12% of the Forest. Alternatives 3, 7, and 6, have approximately 8%, 7%, and 6% of the Forest, respectively, assigned 0 mi/mi^2 total road density. Alternatives 2, 5, 9 and the Selected Alternative all propose a goal of 5% of the land base in areas of 0 mi/mi^2 total road density. Alternative 1 does not have a 0 mi/mi^2 total road density upper limit except in existing Wilderness.

Table 3-14 shows that areas assigned an open road density upper limit of 0 mi/mi^2 display a similar pattern across the range of alternatives, with Alternative 4 having the largest area assigned a 0 mi/mi^2 open road density. The difference between open roads and total roads is that open roads are in use more consistently and are therefore more likely to have more NNIS infestations. The total road figure includes closed roads that are only occasionally used for management activities. These closed roads are less likely to have infestations of NNIS at this time.

Table 3-14. Area (in acres) of 0mi/mi^2 of Open Road, Total Road Density that will Limit NNIS Habitat Creation, and Potential Open Road Density for the Whole Forest, by Alternative

Contributing Factor	Alt.1 C/N	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6	Alt.7	Alt.9	Sel. Alt.
Area managed for total road density (5, 5B, 6A)	44,000	62,000	117,000	192,000	80,000	93,000	112,000	75,000	64,000
Area managed for open road density	125,000	151,000	281,000	342,000	200,000	252,000	278,000	234,000	170,500

Recreation trails, especially those that receive concentrated soil disturbance like ORV trails (including ATVs), provide excellent NNIS habitat and provide corridors and transport mechanisms to facilitate their spread. In general, fewer miles of ATV trails on the landscape result in fewer opportunities for NNIS populations to spread across the Forest. Table 3-15 shows that there are presently 284 miles of ATV trail available on the Chequamegon National Forest. Alternatives 2 and 9 would add up to 110 miles of ATV trails and connectors to the Chequamegon and up to 180 miles of ATV trails and connectors to the Nicolet. Alternatives 5 and 6 potentially add 85 miles of ATV trails/connectors to the Chequamegon and 50 miles to the Nicolet. The Selected Alternative proposes a maximum of 100 miles of new ATV trails on the Chequamegon and 85 miles on the Nicolet for a total of up to 469 miles of ATV trails forestwide. Alternative 1, the current condition, is the only alternative to permit off-trail (cross-country) ATV activity.

Closure of ATV Play Area 26 on the Washburn Ranger District south of Moquah Barrens Wildlife Area under Alternatives 2-9 and the Selected Alternative is likely to limit the risk of spread of NNIS by reducing the amount of disturbed area where the NNIS could become established and by reducing the number of potential NNIS vectors (ATVs) in the area. Revegetation and the use of NNIS-free fill at the site are likely to be needed to rehabilitate the area and further protect against the spread of NNIS.

Alternative 4 is the only alternative that does not include any potential OHV (4WD) recreational opportunities. Alternatives 2, 5 and 6 propose doubling, from 25 to 50, the number of miles currently available. Alternatives 1, 3, 7, 9 and the Selected Alternative maintain one existing 25-mile OHV trail.

Table 3-15. Miles of ATV and OHV Trails and/or Connectors Available by Alternative, and Acres of Non-Motorized Recreation Areas.

Contributing Factor	Alt.1 C/N	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6	Alt.7	Alt. 9	Sel. Alt.
Total ATV trail miles potentially available (in miles)	284	574	324	284	419	419	384	574	469
Potential NEW ATV trails and connectors on Chequamegon (in miles)	0	110	20	0	50	50	50	110	100*
Potential NEW ATV trails and connectors on Nicolet (in miles)	0	180	20	0	85	85	50	180	85*
Existing ATV trails and connector routes on the Forest	284	284	284	284	284	284	284	284	284
Miles of OHV (4-Wheel Drive) designated trail potentially available (in miles)	25	50	25	0	50	50	25	25	25
Total Acres of Non-Motorized Recreation Areas (in acres)	125,000	151,000	281,000	342,000	200,000	252,000	278,000	234,000	193,000

** No distinction is made between "trails" and "connectors" in the Selected Alternative and 2004 Forest Plan. See the "ATVs and Off Road Vehicles" section of this chapter for more information.*

Some NNIS species, like garlic mustard, can thrive in low light conditions under the tree canopy. These species pose the most severe threat to forest understory biodiversity, and can spread readily from road and trail edges. Those areas with fewer or no roads and trails should be less vulnerable to NNIS invasion. As shown in Table 3-15, Alternative 4 proposes the most acres for non-motorized recreation (342,000 acres). Alternatives 3 and 7 propose about 60,000 acres less than Alternative 4, followed by Alternatives 6, 9, 5, the Selected Alternative, 2, and 1. The Selected Alternative designates 193,000 acres as non-motorized, 7,000 acres less than Alternative 5.

Recreational vehicles, boats, and trailers can transport aquatic and wetland NNIS seed and vegetative matter and make it possible for these species to spread and degrade aquatic and wetland habitats (WDNR 1997b). Table 3-16 shows that Alternatives 3, 4, 7, and 9 provide for the most miles of stream in non-motorized areas, reducing the miles of streamside habitat vulnerable to infestation (272, 274, 181, and 186 miles, respectively). Alternatives 4, 7, and 6 provide for the largest amount of lakes in non-motorized areas. This will limit the potential for the introduction of aquatic NNIS plants from boats and boating equipment in 6,060, 5,550, and 5,370 acres of lakes, respectively.

Table 3-16. Acres and Number of Lakes, Ponds, Backwaters and Flowages Larger than 10 acresand Miles of Stream Occurring in Non-Motorized Areas.

	Alternative								
	1 C/N	2	3	4	5	6	7	9	SA
Lakes, ponds, backwaters, and flowages larger than 10 acres*	1,700	3,940	5,250	6,060	4,630	5,370	5,550	5,010	4,280
Number of Lakes	42	69	95	106	83	93	101	92	77
Perennial Stream Miles	~100	128	272	274	144	150	181	186	120

**Includes all waters even if there is no adjacent FS ownership.*

Aquatic and wetland NNIS are transported between habitats by recreational vehicles, boats, and trailers. Therefore, lakes and streams found in areas where motorized recreation is prohibited may be less likely to become infested. Under the Selected Alternative, 77 lakes, ponds, backwaters, and flowages larger than 10 acres are found within non-motorized areas. Approximately 120 miles of stream under the Selected Alternative fall within non-motorized areas.

Effects of Roads and Trails on Vegetative Composition

The effects of Level 3, 4, and 5 roads are analyzed in greater detail in the Roads Analysis for the Chequamegon-Nicolet National Forests (USDA FS 2002a). A summary of the Roads Analysis is found in Appendix K of the final EIS. Road and trail corridors can have an effect on terrestrial vegetation. Trees and plants are often killed by road construction and/or road rehabilitation activities. Edge and generalist species typically dominate road corridors (Forman 1995). The effect of roads on Non-native invasive species has been discussed previously. Salt, used to melt ice on roads, can have a detrimental effect on pines and cedar, even a considerable distance from road sites (Hofstra and Hall 1971). Vehicle use creates dust that settles on nearby plants and blocks photosynthesis (Trombulak and Frissell 2000). Roads create edge environments that cause physical changes such as increased temperatures and light, lower humidity, and biological changes such as predator density. For example, a Washburn District study by Saunders et al. (1998) found that roadway temperature changes persist at a distance up to 10 times greater than the width of the road. Plant distribution can be greatly modified by temperature changes (Xu et al. 1997).

Paved (Findlay and Houlahan 1997), unpaved, and temporary roads (Brosofske et al. 1999) influence plant species diversity. Even skid trails and haul roads necessary for timber harvest have a significantly higher number of introduced species and wetland species (introduced as a result of compaction) (Buckley et al. 2002). The existing Chequamegon-Nicolet National Forests' road system occupies about 2.2% of the land base. Although we cannot predict by alternative the number of skid trails and haul roads, these features are directly linked to timber harvest activities**.** All alternatives propose to impact between 18,000 and 22,000 acres annually (Figure 3-25). For comparison, timber-harvesting activities on the Chequamegon-Nicolet National Forest during 1989-2003 directly

impacted an average of 18,700 acres. Therefore, the impacts of timber-harvest related roads and trails are projected to increase. This could lead to further impacts on species diversity, either directly or indirectly through edge effects.

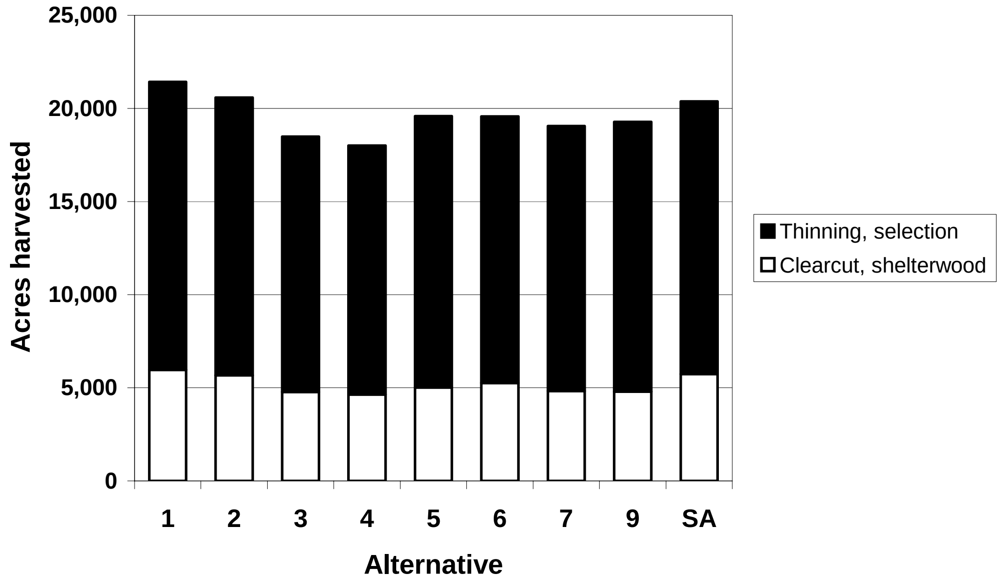

Figure 3-25. Average Annual Timber Harvest Acres in the First Decade.

The desired average forestwide total road density does not vary by alternative and remains at 3.0 miles per square mile. Total road densities are expected to decrease in all alternatives, from current levels of approximately 4.41 and 5.40 roads per square mile for the Chequamegon and Nicolet, respectively, simply due to road decommissioning needed to meet the density goals set in the 1986 Forest Plans (approximately 3.0 miles per square mile). Approximately 2000 miles of roads would need to be decommissioned to meet existing road density goals of 3.0 miles per square mile across all alternatives. The Forest has decommissioned about 50 miles of roads per year in the past. Priority for decommissioning in the Forest Plan would be in areas where resource damage is taking place and in Management Areas 5B and 6A.

There is some variation across alternatives in terms of potential miles of new All-Terrain Vehicle (ATV) and Off-Road Vehicle (ORV, includes 4-Wheel Drive vehicles) trails (Table 3-15). Alternative 2 and 9 provide potential for the highest mileage of motorized trails and connectors (574 miles). The Selected Alternative ranks third highest with a maximum of 469 miles of ATV trails. (No distinction is made between “trails” and “connectors” in the Selected Alternative and 2004 Forest Plan. See the “ATVs and Off Road Vehicles” section of this chapter for more information). Alternatives 3, 5, 6, and 7 are in the middle range. Alternatives 1 and 4 provide for no new trails or connectors (See Table 3-15).

The effects of roads and trails on the Forest landscape are discussed in the “Landscape Pattern” section of this chapter. Overall, there is little difference in the effect of roads on terrestrial vegetation by alternative. However, the effects of motorized trails on vegetation differ, with Alternatives 2 and 9 likely to have the greatest impact on terrestrial vegetation, followed by the Selected Alternative. Alternatives 5, 6 and 7 would have some impact, and Alternatives 1, 3, and 4 would have the least impact. Disturbance-

associated species including NNIS are expected to increase with ATV trail development, as are physical and biological edge effects associated with the trail corridor.

Effects on Vegetation Structure (stand-level) from Management Area Allocation

Many new Goals, Objectives, Standards, and Guidelines were developed for Alternatives 2-9 and the Selected Alternative which affect vegetation structural diversity at the stand or site level. For example, promoting long-lived super-canopy trees, reserving large old trees, and creating canopy gaps are covered in Forestwide Standards and Guidelines ("Biological Diversity" section, Chapter 2 of Forest Plan). To promote the retention and creation of coarse woody debris, Alternatives 2-9 and the Selected Alternative have a Forestwide Guideline ("Biological Diversity" Guideline, Chapter 2 of the Forest Plan) that calls for maintaining pit and mound micro-topography and reserving large old trees. These forestwide Standards and Guidelines will be applied consistently across all alternatives.

Some Guidelines, however, are specific to particular Management Areas (MAs) and therefore result in greater variation by alternative. Further, each MA has a different desired future condition for vegetation structure (Refer to MA descriptions, Chapter 3 of the Forest Plan). In general, Alternative Management Areas (AMA; MA 2B, 3B, 4B, 4C) provide the greatest emphasis on restoring key elements of vegetative structure of all Management Areas. Figure 3-26 compares the acres allocated to AMAs by alternative.

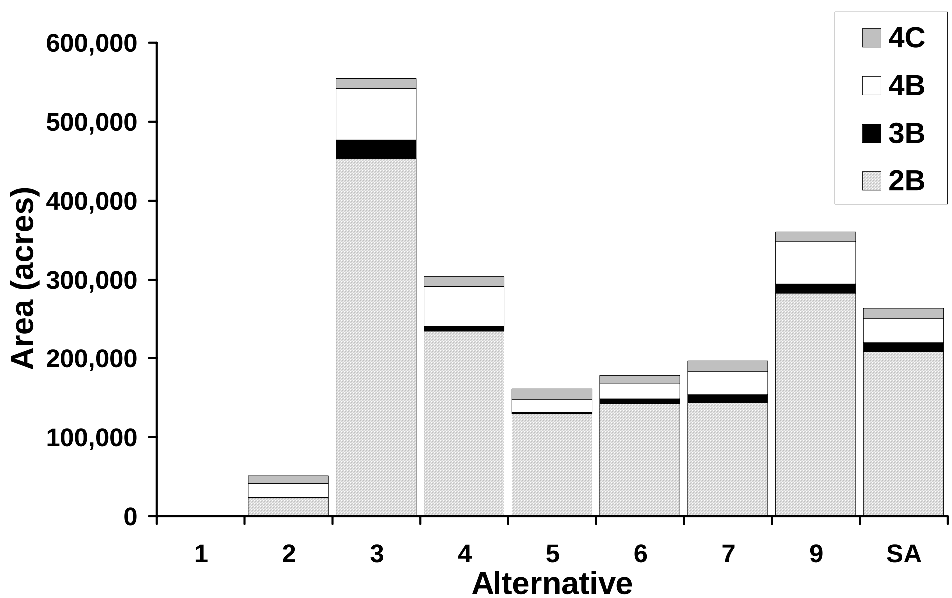

Figure 3-26. Alternative Management Area (MA 2B, 3B, 4B, and 4C) Allocation by Alternative

On the Forests, large-diameter trees are an ecological component that is missing or found in low levels. Large diameter trees can provide desirable or optimal nesting, denning, and foraging habitat for birds and mammals including American marten, red-shouldered hawks, and goshawks (SVE panel notes 2002), and bark-foraging birds (Probst 1992). Uneven-aged northern hardwoods are managed by working toward a desired Basal Area for various diameter classes.

Uneven-age harvest treatments in Alternative 1 call for the harvest of trees exceeding 24 inches in diameter in order to work toward the desired distribution. In addition, approximately 21% (Nicolet) and 26% (Chequamegon) of basal area of trees retained on the site are to occur in the 20 to 24 inch diameter class. Presently, less than 5% of the Northern Hardwood stands on the Forest have the amount of trees in these large diameter classes to meet these percentages. Under Alternatives 2-9 and the Selected Alternative in 20-25 years, perhaps 25-50% of the northern hardwood stands on the Forest could have these amounts of large diameter trees. All uneven-aged northern hardwoods are treated similarly in Alternative 1.

In Alternatives 2-9 and the Selected Alternative there are two regimes for managing uneven-age northern hardwood forests. One is used in MA 2B, 3B, 4B, and 6B to develop trees 25 inches or larger, with 30% of the basal area of trees 19 inches or larger. The intent in these areas is to develop more diversity of tree structure including large trees, standing dead trees, and coarse woody debris while providing timber products. In other MAs, the goal of harvest treatment is to produce northern hardwood sawtimber products with less emphasis on large trees or coarse woody debris. In those areas, the largest size class for northern hardwoods is 21-22.9 inches, with 20% of basal area in trees 19 inches or larger (see Tables 2-4 and 2-5 in the 2004 Forest Plan).

Figure 3-27 compares, by alternative, the number of acres of northern hardwoods within Management Areas 2A, 2B, and 2C that are expected to be managed under the three regimes described above. Some of the acres displayed could be managed under an even-aged hardwood system due to the species present on a particular site. However, the assumption is made that most acres of northern hardwoods within Management Area 2 would be managed as uneven-aged hardwoods. Therefore, Management Areas 2A, 2B, and 2C emphasize uneven-aged hardwood management and are used as an indicator to compare emphasis on larger diameters across alternatives.

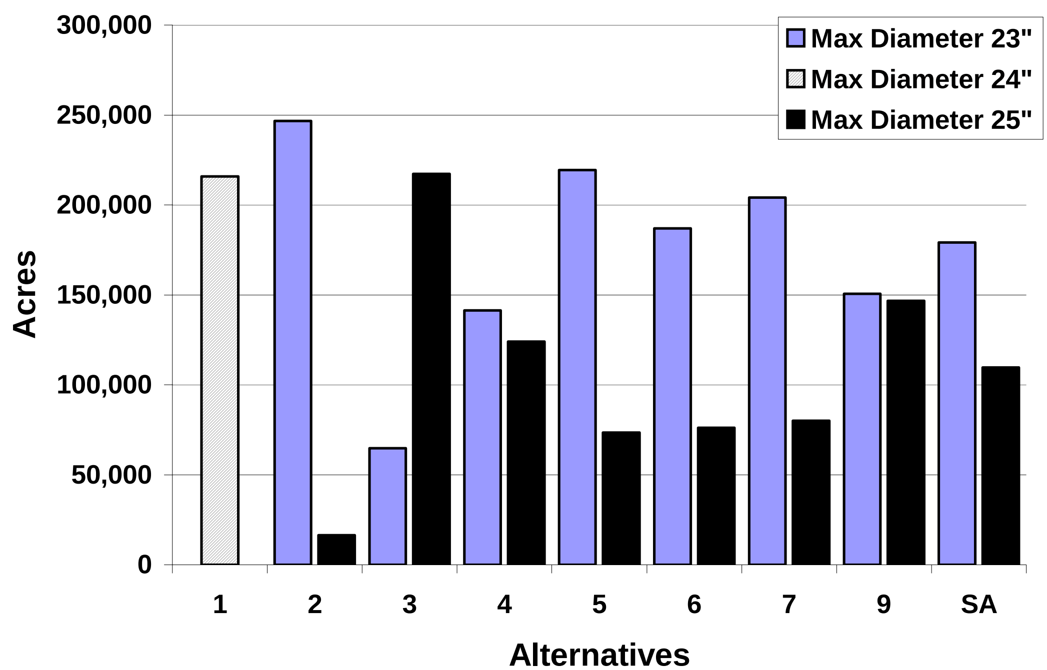

Figure 3-27. Diameter Emphasis in Northern Hardwoods

Guidelines for live trees reserved during harvest actions in uneven-aged managed stands also vary by alternative, with MA 2B, 3B, and 4B emphasizing more reserve live trees per acre and more trees in the larger size class (see Management Area prescriptions, Chapter 3 of Forest Plan). Figure 3-28 displays the proportion of northern hardwoods assigned to these MAs by alternative. Alternative 3 has a much higher proportion (68%) of northern hardwoods managed for larger diameter live trees, larger reserve trees, and more reserve trees, followed by Alternatives 9 and 4. The Selected Alternative allocates 37% of the Forest's suited northern hardwoods acres to Management Areas 2B, 3B and 4B. Alternatives 7, 6, and 5 have fewer acres with this emphasis and Alternatives 1 and 2 have few or no acres with this emphasis.

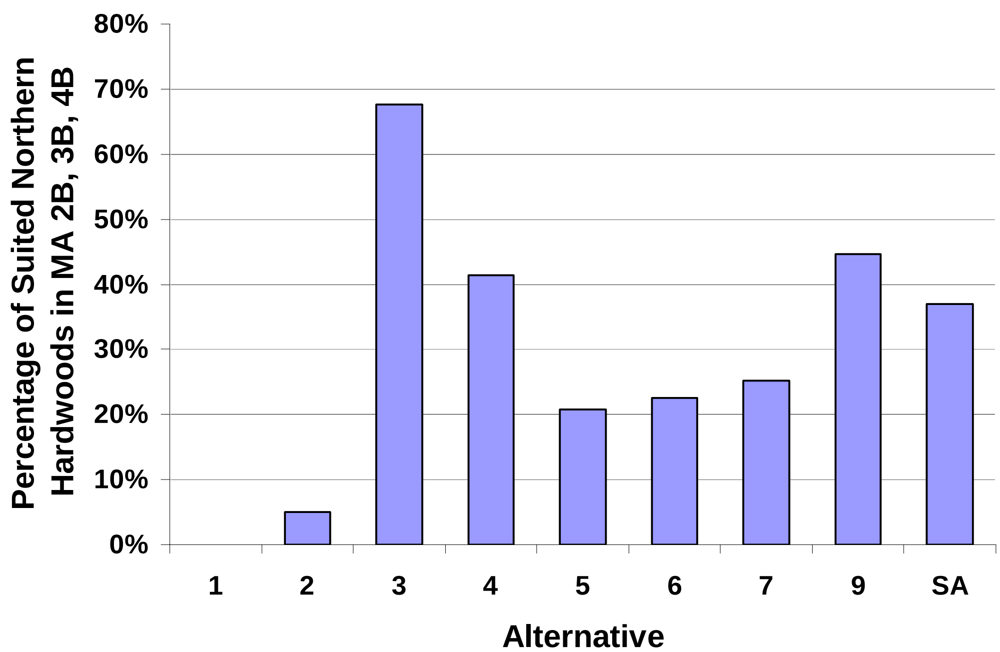

Figure 3-28. Proportion of Suited Hardwoods Occurring in MA 2B, 3B and 4B

Rotation ages vary by alternative, due to different management area allocations. Extended rotation ages (as stated in Rotation Length Guidelines in “Vegetation Management” section, Chapter 2 of the Forest Plan) apply to all tree species in MAs 2B, 3B, and 4B for Alternatives 2-9 and the Selected Alternative. Standard rotation ages apply to other Management Areas, including those in Alternative 1.

For example, red pine and white pine in MA 4B would be regenerated at 175 and 200 years, respectively, as compared with standard rotation ages (100 and 120 years) for red and white pine in other MAs. Even-aged northern hardwoods in these MAs have an extended rotation age of 140 years, compared with a standard rotation age of 100 years. Paper birch has an extended rotation age of 80 years, and a standard rotation age of 60. Aspen is harvested at the extended rotation of 70 years in MA 2A, 2B, 3B, and 4B.

Figure 3-29 displays the proportion of suitable acres of red/white pine that are allocated as MA 4B, thus having an extended rotation age. Alternative 3 has the highest amount (13%) of suited pine allocated as MA 4B, followed by Alternatives 9 and 4 at 10-11%. The Selected Alternative has 7% of the Forest's suited pine in MA 4B. Alternatives 2, 5, 6, and 7 are similar at 4-6%. Alternative 1 does not include any MA 4B areas.

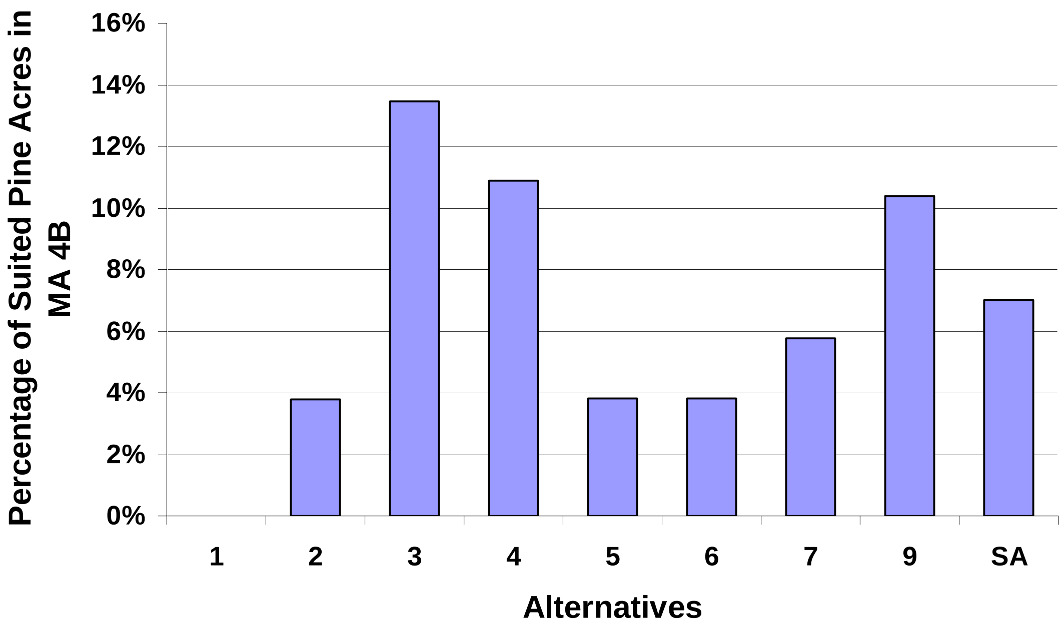

Figure 3-29. Proportion of Suited Red and White Pine in MA 4B

Structural diversity within naturally regenerated jack pine stands is higher than in older jack pine plantations due to a greater diversity of shrubs, residual trees, grasses, forbs, and coarse woody debris. See the “Vegetation Composition” section for more discussion of this issue.

While unsuited acres include areas such as swamps, lowlands, and riparian areas, some unsuited acres are designated as Wilderness (MA 5), potential Wilderness (MA 5B), and Semi-Primitive Non-Motorized with low disturbance (MA 6A). In such areas, more structural features such as downed logs, large trees, snags, and den trees could be retained than in areas managed for timber.

Alternative 4 has the most unsuited land and Alternative 1 has the least (Figure 3-30). Some of the potential Wilderness (5B), and Semi Primitive Non Motorized (SPNM) low-disturbance areas (6A) lack many structural features as a result of past actions. Such areas will develop these attributes over time in the absence of timber harvest.

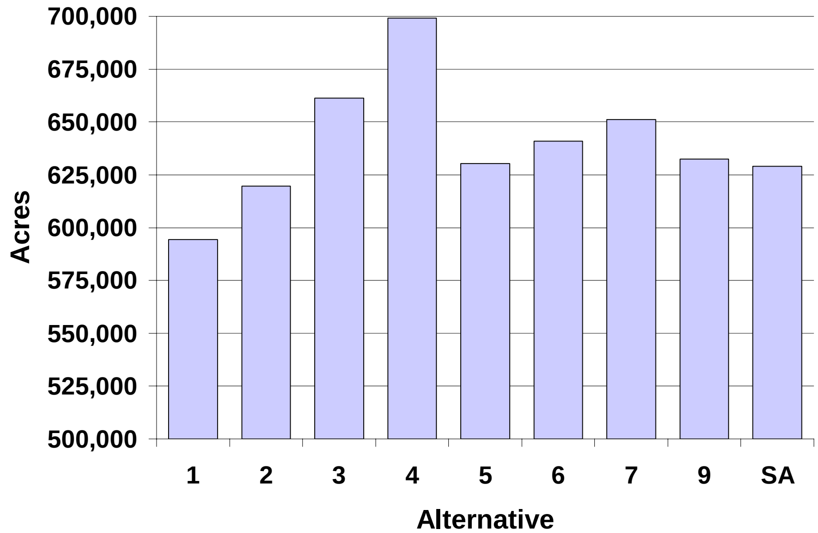

Figure 3-30. Unsuited Land by Alternative

Management Areas that are candidates for ecological reference areas (MA 8E, 8F, and 8G) (ERA's) were selected because they possess many important structural elements. One indicator of the amount of structural features to be found within MA 5B and 6A is the amount of ecological reference areas designated within them. Figure 3-31 illustrates the degree of overlap between ecological reference areas and potential Wilderness areas (MA 5B). The average overlap between proposed Wilderness areas and ecological reference areas among action alternatives is 18%. Alternative 4 contains the most acreage of potential Wilderness areas and the most ecological reference areas within those potential Wilderness areas. Approximately 25% (3,800 acres) of MA 5B is overlapped by MA 8E, 8F, and 8G areas in the Selected Alternative.

Similarly, Figure 3-32 illustrates the degree of overlap between ecological reference areas and potential SPNM low-disturbance areas (MA 6A). These areas are likely to provide important structural vegetation elements in a shorter time, due to the relatively high degree of overlap with areas of higher ecological quality (ecological reference areas). While total amount of MA 6A varies, Alternatives 4, 3, and 7 provide the greatest overlap of ecological reference areas with MA 6A areas. The Selected Alternative has 11,000 acres (approximately 56%) of overlap between MA 6A and Ecological Reference Areas. The Selected Alternative ranks fourth highest among Alternatives in ERA overlap with MA 6A. Alternative 1 does not include MA 6A.

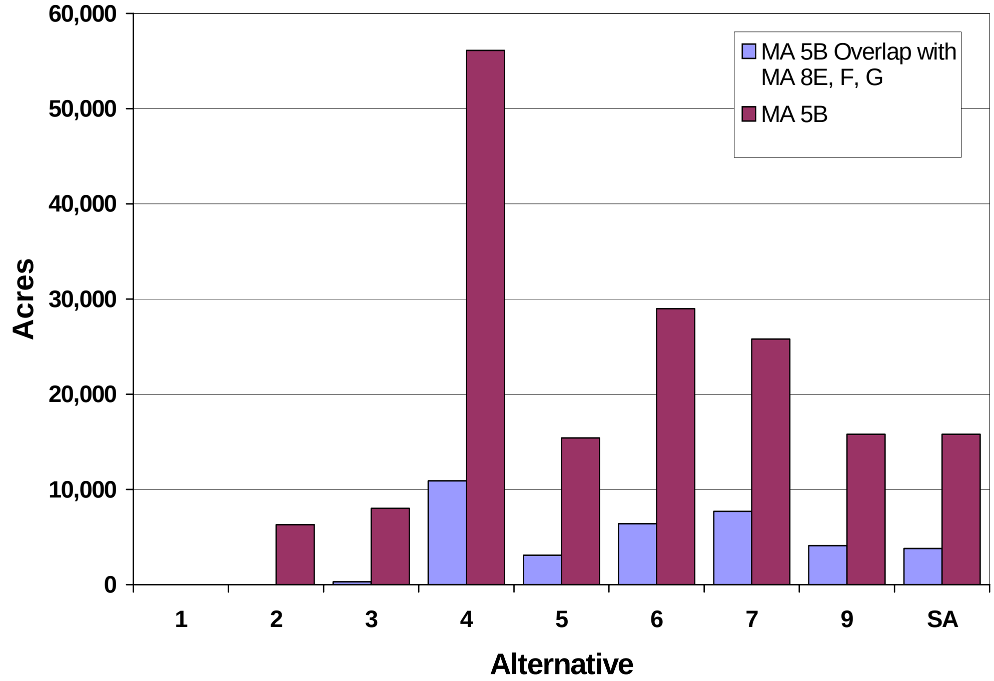

Figure 3-31. Overlap of Ecological Reference Areas with MA 5B

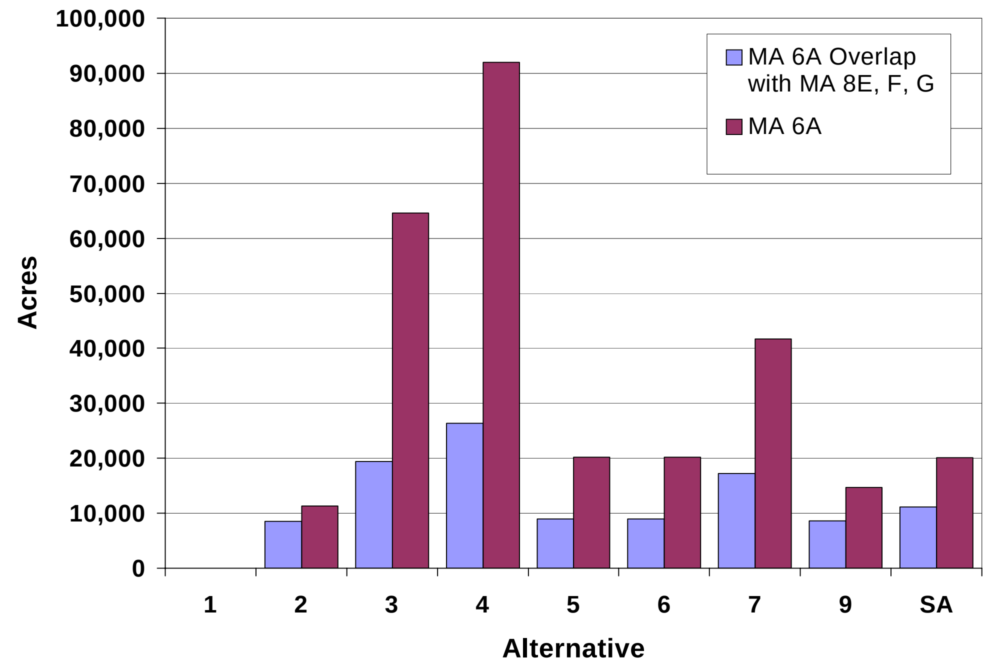

Figure 3-32. Overlap of Ecological Reference Areas with MA 6A

Overall, Alternative 1 will provide the least restoration of desirable vegetation structure. None of the new proposed Forestwide Standards and Guidelines aimed at improving vegetation structure apply to this alternative, and Alternative 1 has no Alternative Management Areas emphasizing restoration and maintenance of stand-level structural features. Alternative 3 benefits vegetation structure the most of all alternatives, providing more variation in tree diameters and more residual live trees and coarse woody debris. Alternatives 4 and 9 also have positive effects on vegetation structure, although to a lesser degree than Alternative 3. Alternatives 5, 6, 7, and the Selected Alternative have similar effects and, based on the above indicators, these alternatives rank approximately midway between Alternative 1 and Alternatives 4 and 9. On lands not managed for timber, structural diversity will be maintained or increased through natural disturbance processes.

Effects on Terrestrial Ecosystem Function from Management Area Allocation

This section focuses on disturbance, a major terrestrial ecosystem function. As noted in the "Comparison of Present Conditions to RNV" section, a dramatic change occurred in the type, frequency, and severity of forest disturbances. Today, timber harvest is one of the principle forest disturbance agents. The alternatives vary in terms of the amount, intensity, frequency, and timing/seasonality of disturbance. First, there are small differences in the number of acres subject to harvest activities in a given year. In general, there is little difference between alternatives – a difference of 2,600 acres between the highest (Alternative 2; 20,600 acres) and the lowest (Alternative 4; 18,000 acres). The Selected Alternative projects that 20,100 acres will be shelterwood or clearcut harvested annually in the first decade of implementation of the 2004 Forest Plan. By comparison, 21,400 acres would be harvested annually under the 1986 Plans (Alternative 1).

Disturbance intensity varies by alternative. For example, some alternatives result in more acres treated with even-aged management methods, including clearcuts and shelterwood harvests. Figure 3-25 compares the average annual number of acres treated with methods that create openings (clearcuts and shelterwood harvests) and acres treated with methods that do not create openings (thinning and selection).

Even-aged northern hardwood management (typically shelterwood harvests) can occur within MAs emphasizing uneven-aged hardwood management. (See Management Area 2 desired vegetation composition, Chapter 3 of the Forest Plan). In Management Areas 2A, 2B, 3B, and 4B, aspen is harvested at the maximum rotation (70 years) increasing the interval between disturbances.

Disturbance frequency also varies by MA assignment, and thus by alternative. For example, MA 4A and 4B differ in the return interval of pine thinnings (7-15 years and 10-20 years, respectively). Disturbance size varies, too. MA 4C emphasizes large temporary openings serving as surrogate pine barrens and complementing nearby restored pine barren core areas. MA 4C jack pine clearcuts are as large as 1,000 acres, compared with a 40-acre maximum in other MAs, except with possible public notice and Regional Forester review. (See Vegetation Management Standard, in Chapter 2 of Forest Plan). Table 3-17 compares the percent of suited jack pine located in MA 4C by alternative. Alternatives 3, 4, 7, 9 and the Selected Alternative have 13% of suited jack pine in MA 4C; Alternatives 2 and 6 have 10%Alternative 1 has none).

Table 3-17. Acres of Jack Pine within MA 4C and other Management Areas

	Alternative								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**SA**
Suited Jack Pine in MA 4C	0	3,000	4,000	4,000	4,000	3,000	4,000	4,000	4,000
Suited Jack Pine in all other MAs	30,000	28,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000
Percent of Suited Jack Pine in MA 4C	0%	10%	13%	13%	13%	10%	13%	13%	13%

Harvest timing or seasonality also varies by alternative. MA 2B has a guideline emphasizing frozen-ground conditions for timber-harvesting in northern hardwood stands. Table 3-18 compares the percent of suited hardwoods occurring in MA 2B, by alternative.

Table 3-18. Proportion of Suited Hardwoods that are in MA 2B

	Alternative								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**SA**
Suited N. Hardwoods in MA 2B (in thousands of acres)	0	15	193	110	65	67	71	131	110
Suited N. Hardwoods in all other MAs (in thousands of acres)	337	306	106	173	253	243	235	183	223
Percent of Total Suited NH in MA 2B	0%	5%	65%	39%	20%	22%	23%	42%	33%

Fire and Wind

Fire suppression efforts are similar in MAs in all alternatives. Prescribed fire as a management tool is recommended in several MAs for site-preparation, stand maintenance, or ecosystem restoration. MA 4C (surrogate barrens), 4B (natural pine-oak), 3B (even-aged hardwood oak-pine), and 8C (Riley Lake Wildlife Area and Moquah Barrens Area) all encourage fire for the above-mentioned reasons. Figure 3-33 compares the amount of these MAs, by alternative. The Selected Alternative allocates 5% of the Forests to Management Areas with an emphasis on prescribed fire. Alternatives 3 and 9 have the most acreage of MAs emphasizing prescribed fire as a management tool (7-8%). Alternatives 4 and 7 are moderate in emphasis on prescribed fire and Alternatives 1, 2, 5, and 6 have the fewest acres with this emphasis (1-3%).

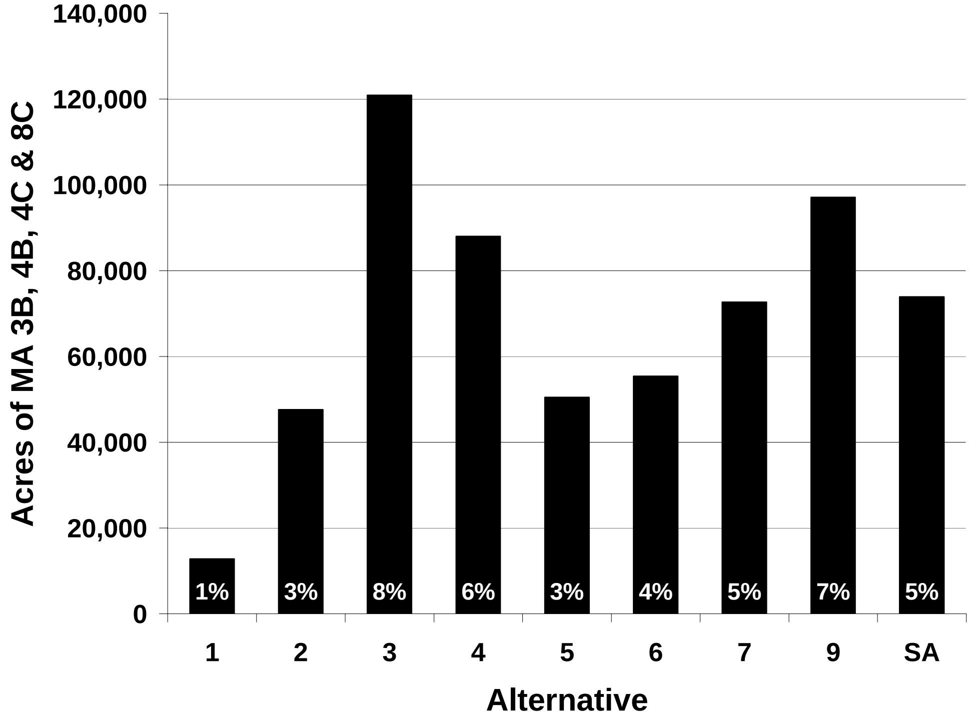

Figure 3-33. Prescribed Fire Emphasis (Management Areas 3B, 4B, 4C, and 8C) and the Percentage of the Forest that these MA Allocations Comprise

Although natural disturbance regimes have been considerably altered from past conditions, large-scale natural disturbances still occur on the Forests. Windstorms are the most common natural disturbance. Leaving a portion of naturally disturbed areas un-harvested can improve forest structure (by increasing coarse woody debris and residual stems) and restoring tree species such as white pine (Crow et. al. 1994; Frelich and Reich 1996; Frelich 2000). Table 3-19 compares the amount of area where natural disturbance prevails in Wilderness, Potential Wilderness, and Semi-Primitive Non-Motorized (SPNM) low disturbance areas.

Table 3-19. Acres of Management Areas where Natural Disturbance Prevails

	Alternative								
	1	2	3	4	5	6	7	9	SA
Acres of MA 5, 5B, 6A	44,000	62,000	117,000	192,000	80,000	93,000	112,000	75,000	64,000

On suited lands, MA 2B, 3B, and 4B have provisions for leaving a portion of potential salvage areas un-harvested, with appropriate forest health and human safety considerations. Figure 3-20 provides a comparison of the amounts of these MAs by alternative.

Mammalian Herbivory

Browsing and grazing by white-tailed deer is a low-intensity type of disturbance contributing to severe regeneration problems for white cedar, yew, hemlock, white pine, red oak (Beals et al. 1960; Frelich and Lorimer 1985) and species of the lily family (Augustine and Frelich 1998; Balgooyan and Waller 1995). The variation in deer herbivory impacts among the alternatives is analyzed in the section on "Landscape Patterns."

Effects of Road and Trail corridors

Road and trail networks can disrupt landscape processes, such as plant dispersal and natural disturbance (Forman and Alexander 1998). Variation in miles of roads and trails among alternatives is discussed in more detail in the section on "Effects of Roads and Trails on Vegetative Composition."

Effects on Soils from Vegetation Management Activities

The bounds of analysis for determining direct and indirect effects of proposed activities on the Chequamegon-Nicolet National Forests' (CNNF) soil resource are the land type associations within the Forests boundaries. These ecological units define areas of different biological and physical conditions at a landscape scale. The effects of potential ground disturbance or vegetation removal are confined to the soil in an LTA directly beneath the activity. For example, operating machinery to cut and remove trees in one LTA would generally not affect the soil in another LTA within or outside the Forests' boundaries.

During forest plan revision, boundary lines for MAs 1-4 were delineated based on LTA mapping and information. The MA boundaries remain constant for Alternatives 2-9 and the Selected Alternative, although the MA allocations within the boundaries differ among alternatives. The landscape description paragraph in each Management Area Prescription (Chapter 3, Forest Plan) lists the LTAs occurring within that particular MA, with some general characteristics. Full LTA characterizations are available at CNNF offices.

National and Regional soil quality standards set acceptable limits to identify detrimental soil disturbance (USDA FS, 1991, 2001a). Detrimental soil disturbance is defined as the condition where accepted limits of change for soil properties are exceeded and result in major changes in soil quality and productivity.

The effects of alternatives were assessed to determine if the degree and extent of potential soil disturbance would cause sufficient change in soil properties to be considered detrimental to the soil resource. Alternatives 1-9 and the Selected Alternative propose management actions that have the potential to impact soil properties through erosion, displacement, compaction, rutting, burning, and nutrient removal. The type and amount of management activities are similar among Alternatives 1-9 and the Selected Alternative, allowing direct and indirect effects to the soil resource to be discussed together in this section. The extent, intensity and duration of potential effects have been estimated based on the following:

- Applicable research;
- Technical soils and ecological unit information;
- Standards, guidelines, design features and mitigation measures;
- Wisconsin Forestry Best Management Practices;

- Monitoring of past activities on similar soils; and
- Professional experience and judgment of soil scientists and resource specialists.

Of the 1,494,000 acres of CNNF land, 1.3% to 1.5% is projected to have potential ground disturbing activities proposed annually through the first decade for Alternatives 1-9 and the Selected Alternative. These activities would occur on suitable Forestlands across the range of LTAs. This would leave more than 98.5% of the CNNF landbase with no potential ground disturbing activities planned annually, and more than 85% of the Forests untreated for the entire decade. The percentage of land actually impacted is further reduced because less than 15% of an average harvest treatment area would actually be operated on with equipment. This trend is projected to continue into the 5th, 10th and 15th decades for all alternatives, with less than a 1% increase in projected acres treated over this time. Thus, the potential for broad scale impacts to CNNF soil resources is limited for all alternatives.

Effects on Soils from Timber Harvest Activities

Surface erosion occurs when all vegetation and organic matter is removed, exposing mineral soil to rainfall. Soil displacement occurs when surface soil layers are mechanically relocated. Soil compaction and rutting can occur if heavy machinery is operated on saturated soils. Nutrients are removed when harvested wood products are taken off-site. Timber harvesting proposed in Alternatives 1-9 and the Selected Alternative has the potential to directly impact the soil resource when machinery is used to fell and transport tree boles, and when landing areas are cleared to store wood until it is trucked away. After harvest, mechanical site preparation for seeding or tree planting also has the potential to expose, displace, compact, or rut soils. An indirect effect of timber harvesting would be the removal of nutrients in wood products to an extent that long-term productivity could be impaired. Other indirect effects include the potential to reduce carbon storage or increase nitrate leaching.

The potential for detrimental soil erosion and displacement from timber harvest activities is low for all proposed harvest areas on the CNNF. Annual timber sale monitoring across the CNNF indicates only minor short-term mineral soil exposure from harvest operations and minor long-term soil displacement. Tracked or rubber-tired harvesting equipment operates on top of surface rock, forest floor litter and limbs from harvested trees. The average ground area traveled by machines in a typical harvest operation on the CNNF is less than 11% of a sale unit for all harvest types. Scattered areas of exposed soil from machines maneuvering on uneven ground will re-vegetate naturally within one or two growing seasons and are not an erosion concern. Sale unit boundaries avoid steep slope areas. Because of gently rolling terrain, it is generally not necessary for equipment to operate up and down long steep slopes on the CNNF. Water diversion structures such as water bars would be constructed in accordance with BMPs and FSH 2509.22 where temporary roads and main skid trails occur on short steep slopes. Harvesting equipment does not generally remove the surface organic or mineral soil layers. Therefore, soil displacement rarely occurs in the treatment area.

Most harvest operations haul cut-to-length wood to a landing on a rubber-tired forwarder. However, when thinning red pine the whole tree bole may be skidded to the landing. Dragging the limbed treetops along the ground will cause some mixing of the organic and mineral soil materials, but this is not considered detrimental displacement. Existing landings are often used or new landings are located next to roads where no ground clearing is needed. Some soil would be exposed and displaced when stumps or rocks

need to be cleared to establish a new landing or spur. Soil erosion potential is low because sale administrators approve level, well-drained areas and ensure the area is re-vegetated naturally or seeded within two growing seasons after operations cease. Main skid trails near landings would have more exposed mineral soil due to repeated use. These areas normally re-vegetate naturally in one growing season. Mechanical site preparation of 900 to 1,700 acres for planting or seeding is proposed annually for the first decade. Site-specific prescriptions would require machines to spot scarify or remove logging debris on planting sites, or mix the organic and mineral soil layers in preparation for artificial or natural seeding. Minimal amounts of soil would be exposed and displaced in these processes, but no detrimental erosion or displacement would occur.

The potential for detrimental soil compaction or rutting from timber harvesting is low. Annual CNNF timber sale monitoring indicates only minor long-term effects due to soil compaction and rutting. Approximately 22% of the Forests have fine sandy loam or silt loam soils where harvest machinery would cause compaction and rutting if operations occurred when the soil is saturated. These soils are primarily within LTAs comprised of loess (windblown) covered drumlins, ground moraine, and outwash landforms, with mesic northern hardwood plant communities.

Project level analysis would identify specific sites where harvest would be limited to frozen or dry ground conditions. This seasonal restriction for equipment operation has been very successful in eliminating potential soil impacts from compaction and rutting on the Forests (USDA Forest Service, 2000e, 2002b and c). Five years of a long-term site productivity study concluded that harvesting aspen when soils were frozen had little effect on physical soil properties and produced a fully stocked stand of aspen suckers (Stone and Elioff, 1998d, p 56-57).

Potential for soil compaction and rutting is also reduced when using low ground pressure equipment (tracked harvesters and wide rubber-tired forwarders) and when operating over compacted snow, forest floor litter, logging slash, and surface rock. Main trails near log landings have repeated use by forwarders. Therefore, a higher potential for impacted soil exists at these locations depending on moisture conditions at the time.

There would be an increase in soil bulk density on the main haul trails. High use trails typically occupy less than 5% of a Forest harvest unit and, along with landings, are often reused for the next harvest (10-20 years later for selection cuts or 35-70 years later for clear-cuts). Mechanical site preparation for seeding or planting would be done under dry ground conditions to minimize the potential for soil compaction or rutting. CNNF monitoring to date indicates no harvested areas with reduced productivity due to soil compaction or rutting (USDA Forest Service, 1998, p 65).

The potential for harvest activities to detrimentally reduce inherent soil productivity is low in the alternatives. Cutting trees and removing the merchantable bole would remove some nutrients from harvested areas. The ratio and amount of nutrients in the bole and bark of trees varies by species, age, stocking, and site quality, but is generally less than one half of the nutrients found in the whole tree and accounts for a relatively small portion of total site nutrients. A major portion of the nutrients taken up annually into the above ground components of trees is returned to the soil in litter fall and canopy wash resulting in a long-term accumulation of nutrients in the surface of mineral soils under forests (Pritchett and Fisher, 1987, p 196). Alternatives 1-9 and the Selected Alternative propose the removal of 20% to 40% of existing overstory trees using a selection, intermediate, or shelterwood cut on 14,490 to 15,940 acres annually for the first decade. This harvest method will not remove excessive amounts of nutrients because a large

percentage of the total site nutrients remain in the cut treetops and limbs (slash), uncut trees, shrubs, organic matter, roots and mineral soil. There is little direct evidence that nutrient removals in biomass harvesting trigger declines in soil productivity (Powers et al., 1998, p 57). Alternatives 1-9 and the Selected Alternative propose clearcutting between 3,600 and 5,570 acres annually for the first decade, removing all merchantable bole wood from the harvest area. Alban and Perala (1990, p 389) found that merchantable bole harvesting of mature aspen stands in Minnesota and Michigan did not affect forest floor weight, soil carbon, or nutrients (nitrogen, phosphorous, calcium, and magnesium). They found that within five years the clearcut sites were fully re-vegetated, litter fall had returned to normal, and nutrients accumulated in the perennial vegetation tissues were as great as the amounts left in logging slash. Accelerated nutrient leaching below the rooting zone after aspen harvests is quite small and short lived (Silkworth and Grigal, 1982, p 630; Verry, 1972, p 283).

The CNNF would continue the current guideline requiring the retention of all treetops and limbs at the stump on sandy soils that are inherently nutrient poor. Stone et al. (1999, p 182) recommended limbing at the stump and retaining slash on site to maintain productivity when harvesting aspen on sand soils. Leaving logging slash on-site is common practice for all types of harvest on the CNNF. Logging slash contains three to four times more nutrients than annual litter fall and can be considered replacements for litter fall nutrients (Alban and Perala, 1990, p 389).

Harvest activities proposed in Alternatives 1-9 and the Selected Alternative will have no adverse effects on total ecosystem carbon storage. Recent studies in the Lake States documented the distribution of soil and biomass carbon in red pine and hardwood forests before and after harvest. They concluded that, in general, tree harvesting reduced carbon storage slightly, but not significantly when considering total ecosystem carbon (Rollinger and Strong, 1995, p 206; Strong, 1997, p 5). Also, there was no difference in total ecosystem carbon between red pine plantations and native hardwood stands (Perala et al., 1995, p 242). Alban and Perala (1992, p 1109) found that neither whole-tree nor conventional harvesting (tops and limbs left on site) had any effect on soil carbon in aspen ecosystems in the Lake States. They also reported finding no evidence that soil carbon changes as succession proceeds from an aspen-dominated community to a northern hardwood community. Johnson reviewed several studies of soil carbon changes after harvesting of forests (1992, p 88). The majority of studies reported no effects or only slight decreases in soil carbon. The overall conclusion was that little (10%) or no change in soil carbon could be expected to occur after forest harvesting alone (Bouwman and Leemans, 1995, p 516). Detweiler (1986, p 75) concluded that managed forests, currently covering 970 Mha worldwide (WRI, 1992), may have no net global effect on the carbon cycle.

Annually, harvesting would occur on a very small percentage of the CNNF landbase for the life of this plan. More than 85% of the 1,494,000-acre CNNF would not be harvested each decade for 15 decades. Harvest activities in Alternatives 1-9 and the Selected Alternative would actually increase above ground carbon storage when remaining trees increase biomass in response to increased light and space from selection and intermediate cuts.

Harvest activities proposed in Alternatives 1-9 and the Selected Alternative would have no adverse impact to soil nitrate levels. Soils of the Chequamegon-Nicolet Forests are not nitrogen (N) saturated. Total soil N varies from less than 0.02% in subsoils to greater than 2.5% for some peats. The average N content for most surface soils ranges from 0.03% to 0.4%. Generally, the amount of total N decreases with depth in the soil profile

(Bremner, 1967, p 19). Soil lab analysis for total nitrogen on 68 sites across the northern Nicolet landbase sampled from 1991-1993 showed N levels to be less than 0.25% in the surface and less than 0.01 % in the subsurface. Under normal circumstances, 90% to 95% of the soil N occurs in a combined organic form, while only 5% to 10% exists either as ammonium, nitrate, or nitrite (Wollum and Davey, 1976, p 74).

Forest soils are generally credited with restricting elemental losses through leaching in temperate forest regions. Elements are retained within a cycle between the plant and soil system and through a general deficiency of anions in a regional forest soil profile. Removal of trees through thinning or clear cutting would increase nitrification. The accelerated release of elements (including nitrates) from the forest floor is utilized by remaining vegetation on these sites or retained in the root zone, with little if any expected loss from leaching. Johnson (1995, p 1351) found that redistribution of soil caused by logging machinery might serve to retain soil nitrogen, at least in the first few years after clear-cutting. Hendrickson et al. (1989, p 731) reported up to 81% higher nitrogen concentrations in the top 20 cm of mineral soil three years after stem-only and whole tree clear-cutting in Ontario.

Harvesting practices in Alternatives 1-9 and the Selected Alternative will preserve organic matter on-site, which will also promote nitrogen retention. Practices that encourage rapid re-vegetation will shorten the period of time during which conditions favor high nitrification rates. National Atmospheric Deposition Program sites located across northern Wisconsin near Spooner, Trout Lake, and Popple River recorded a decreasing annual trend for wet deposition of nitrates and inorganic nitrogen from 1980-1998.

Effects on Soils from Recreation/Access Activities

The potential for proposed access and recreation activities to detrimentally affect the soil resource would be low in Alternatives 1-9 and the Selected Alternative when appropriate design features and mitigation measures are followed. The construction, reconstruction, and closure of roads, trails, and campsites have potential to erode, displace, compact, and rut soils. Building roads and trails exposes mineral soil and has the potential to cause erosion and sedimentation when water is channeled to stream crossings.

The existing CNNF road system, which occupies about 2.2% of the land base, is well developed for timber harvesting and recreation access. Alternative 1 would continue to provide a transportation system based on project and roads analysis needs under the 1986 Forest Plans for the Chequamegon and Nicolet. In the first decade, Alternative 1 would propose to build 93 miles of new road, close 537 miles, and decommission 327 miles of roads.

In Alternatives 2-9 and the Selected Alternative, closure of between 780-900 miles of road and decommissioning between 1,871-1,979 miles would be needed to meet road density goals across the Forests. The Selected Alternative calls for the closure of at least 707 miles of road to meet open road density upper limits, and the decommissioning of at least 1,058 miles to be below total road density upper limits. However, objectives displayed in Chapter 1 of the 2004 Forest Plan call for meeting open road density goals in zero mile/square mile areas, which will require the closure of between 80-230 miles in Alternatives 2-9 and the Selected Alternative. Based on past accomplishments, decommissioning 40 miles of roads annually or 400 miles per decade could be achieved. Project level planning would include a roads analysis process to identify specific roads for maintenance, reconstruction, closure, or decommissioning. Project level analysis

would also identify needs for new road construction. All access activities would follow Standards and Guidelines, BMPs, and road design criteria to minimize soil impacts. The net effect of activities proposed in Alternatives 1-9 and the Selected Alternative would be a reduction in the total open road density and amount of Forest land dedicated to roads. Soil productivity would be restored over time where roads are decommissioned. The potential for soil erosion and rutting would be reduced when unsurfaced forest roads are closed to public access.

Potential miles of ATV/ORV motorized trails and connectors for Alternatives 1-9 and the Selected Alternative ranges from 284-574 miles, including the existing 284 miles of trail on the Chequamegon. Alternatives 2, 5, 6, and 9 propose up to 120 miles of new trail construction. See Table 3-15 for a comparison of the ATV trail and connector route miles by alternative. Project level analysis for trail construction, relocation, and closure would follow site specific Standards and Guidelines and BMPs to minimize impacts to the soil resource. Alternatives 2-9 and the Selected Alternative would not allow cross country use or intensive use/play areas for ATVs. In addition, access to forest roads would be limited to designated locations and time periods. The potential for adverse impacts to the soil resource is greatly reduced by these restrictions compared to the more permissive access allowed by Alternative 1.

Alternatives 2-9 and the Selected Alternative would propose up to 50 miles of designated road or trail for four-wheel drive Off-Road Vehicle (ORV) use. Currently there is one 25-mile ORV trail on the Lakewood district. If monitoring confirms unsafe conditions or unacceptable resource damage, the ORV trail will be closed and a replacement trail of up to 25 miles will be constructed, providing an agreement with a non-Forest Service entity is developed to conduct trail conditioning monitoring and maintenance. Maintenance and monitoring partnership agreements with 4WD clubs would minimize potential soil erosion and sedimentation from this intensive use. Soil compaction, rutting and displacement would be common conditions on these trails. Land dedicated for use as roads or trails is no longer part of the productive land base and is not considered to have detrimental soil displacement or compaction.

Site-specific Standards and Guidelines, BMPs, and design criteria to minimize impacts to the soil resource would also be followed during project level analysis for hiking and camping trails, campgrounds, and dispersed campsites identified for closure, relocation, or new construction.

Effects on Soils from Fire

High intensity fire would have the potential to adversely impact soil properties and can result in reduced soil productivity and erosion. Sandy soils with low organic matter content would be most susceptible to detrimental effects from severe wildfires. The potential for a severe wildfire or prescribed fire to detrimentally burn the soil resource is low. Alternatives 1-9 and the Selected Alternative propose to use prescribed fire for site preparation, restoration, and maintenance of plant communities. The potential for a large catastrophic wildfire event on the CNNF is low and the annual acreage of prescribed burning is estimated to be small (<2,500 acres).

Low to moderate intensity prescribed burning would be done in spring and fall when the litter layer is moist. The intensity and duration of a forest fire determines the effects on the physical, chemical, and biological properties of soil. Prescribed fire on the CNNF would be relatively cool with no large areas of heavy fuel buildup. A portion of understory vegetation and forest floor would be burned. Prescribed fires seldom remove

more than 50% of the surface organic layers and the soil fraction of the A horizon is generally not affected by light burns (Pritchett and Fisher, 1987, p 403). Potential for soil surface erosion is low when the organic layer remains in place. A two-foot wide line of bare mineral soil may be needed to keep fire from spreading outside of burn areas. This exposed soil would seed naturally within 1-2 growing seasons and would not be an erosion concern. Pritchett and Fisher (1987, p 403-416) list the following effects to the soil resource from underburning:

- An increase in available phosphorous, potassium, calcium and magnesium in the mineral soil for 1-5 years.
- Some nitrogen loss through volatilization (minor amounts).
- Temporary increase in nitrogen availability to trees.
- Temporary increase in tree growth due to availability of nutrients.
- Minimal increase in soil temperature during the burn due to moist, insulating humus layer.
- Very minimal increase in soil temperature after the burn because the canopy shades the darkened ground surface.
- Initial decrease in soil microbes/bacteria followed by sharp increase which may occur as soon as the first rainfall following the burn.
- Soil animals such as arthropods (e.g. beetles, ants, centipedes, millipedes, springtails, spiders, ticks, mites) are more numerous after controlled burns.
- Earthworm populations may be decreased due to initial post burn adverse moisture conditions and reduced food supply.

Project level analysis that proposes use of high intensity prescribed burning would follow site-specific mitigation measures to minimize long-term adverse impacts to the soil resource.

There would be no short or long-term detrimental soil disturbance effects from the prescribed burning proposed in the alternatives. The intensity and duration of burns would not be severe and therefore would not impair physical, chemical or biological soil properties.

Effects on Air Quality from Fire Management

Both wildfires and prescribed fires generate smoke and particulates that can temporarily degrade visibility and ambient air quality in downwind areas. The objectives for prescribed fire on the Chequamegon-Nicolet National Forests include wildlife habitat, reforestation, and ecosystem restoration. The area burned each year is limited by climatic conditions that produce a narrow burning window. The average area burned per year for the 16-year period from 1986 to 2001 was 1,263 acres, with a range of 260 to 2,400 acres per year. Most prescribed burns have been performed for wildlife habitat objectives, using mostly grass/shrub fuel types. Some future prescribed fires would be for ecosystem restoration that would include needle and leaf litter on the forest floor for fuels. Some burns would also be for reforestation, which would have light to medium conifer slash as fuels. Based on past data, it is projected that approximately 1,500 acres will be burned each year under all alternatives, with 10% of burns performed for ecosystem restoration, 15% for reforestation, and 75% for wildlife habitat.

Each year there are an average of 25 wildfires that burn 302 acres on the Chequamegon-Nicolet National Forests. The average wildfire is 12 acres. The largest wildfires in the last

few decades and their approximate size include: Foulds Creek, 1,100 acres; Spring Lake, 1,200 acres; Stump, 450 acres; and Sawdust Lake, 50 acres. Most of the Forests' wildfires occur in spring, are less than 5 acres, and burn mostly ground fuels such as grasses and leaf/needle litter. Larger fires tend to burn through young upland conifers (pine plantations or balsam), dead and down conifers, and litter on the forest floor. The overall fuels breakdown is estimated at 85% ground fuels, 10% young conifers, and 5% dead and down conifers.

Approximately 0.12% of the Chequamegon-Nicolet National Forests would burn from prescribed and wild fire each year under all alternatives. The particulate matter emissions for these prescribed and wild fires are estimated to average 85 tons per year. To minimize air quality impacts, all prescribed fires would be conducted according to an approved burn plan that would include measures to minimize smoke problems.

Cumulative Effects on Terrestrial Ecosystems

The Cumulative Effects area for vegetation is Province 212 from the National Hierarchical Framework of Ecological Units (Cleland et al 1997) and is displayed earlier in this section. By definition this area has similar patterns of glacial landforms; historical, existing and potential vegetation; hydrology; fauna; and climatic conditions. For soils, the cumulative effects area includes the land type associations within the Forests boundaries. Since analysis indicated negligible erosion potential, cumulative impacts to soils would not affect adjacent ownership lands within or outside the Forests boundaries.

Past Actions

Numerous historic, natural, and human-caused ground disturbances, such as windstorms, exploitive logging, fires, road- and railroad-building have taken place within the cumulative effects area. Dramatic changes to vegetation composition have occurred in the area in the last 150 years. Intensive and exploitive logging was followed by recurrent fire, agricultural settlement, extensive plantation development, and re-growth of the Northern Forest.

Recent activities, such as timber harvesting and road-building, have occurred over the past 15 years and were implemented using 1986 Forest Plan Standards and Guidelines and site-specific mitigation measures. While the forestland continues to recover from intensive logging at the turn of the 19th century, some characteristics of vegetative communities such as species composition, age class distribution, and structural characteristics are different from those found historically. 1986 Forest Plans placed less emphasis on restoration of ecosystems. Following appeals and litigation of the 1986 Plans, a Scientific Roundtable on Biological Diversity was convened. Panel members provided advice for ongoing Forest Plan implementation and for future Forest Plan Revision. Some of the major factors that were identified that impact ecosystem sustainability include: (1) changes in natural disturbance regimes and landscape-level processes such as fire suppression and changes in location, frequency, and size of forest openings; (2) introduction of exotics; and (3) direct consequences of forest management policies such as inconsistent use of ecosystem restoration knowledge.

Resource specialists conducting field monitoring of project areas on LTAs within the Forest found no short or long-term impairment to soil from recent activities (USDA Forest Service, 1998c, p 65). The Forests have been implementing Wisconsin Forestry Best Management Practices (BMPs) for Water Quality since 1995. Field monitoring indicates that 99% of the time there will be no adverse impacts to water quality from soil

erosion/sedimentation when BMPs are applied correctly (WDNR, 1999b, p 62). Current conditions indicate that key soil properties affecting ecosystem health and sustainability (i.e. porosity, organic matter content and nutrient availability) represent the natural range of soil conditions inherent to the landscapes of the Chequamegon-Nicolet National Forests (USDA Forest Service, 1998a, p 6). Healthy populations of soil microorganisms such as bacteria and fungi exist in the favorable environment of the forest floor litter layer and soil surface organic matter (Pritchett, 1979, p 72). Storage of soil and biomass carbon is increasing in the vegetation and soil. No appreciable long-term effects to soil or land productivity from past activities have been identified in the analysis area.

Present and Future Actions

Vegetation Composition, Structure and Function

Using data collected by the Forest Inventory and Analysis (FIA) (Spencer et al. 1988 and Schmidt 1997), forest cover type data collected in 1983 was compared with the most recent FIA survey (1996) and summarized for 22 Northern Wisconsin counties (Province 212, see Figure 3-3) (WDNR 1999c). Species that are increasing include red pine, tamarack, white spruce, oak-hickory, and maple-beech-birch. Decreasing species include jack pine, white pine, balsam fir, black spruce, northern white cedar, aspen, and paper birch. Assuming these trends hold over the next decade, we can compare them with the predicted change in Chequamegon-Nicolet National Forests' vegetative composition. The predicted 10-year vegetation trends for the Forests are unlike FIA trends because major cover types are expected to change slightly on the Forests in the next 10 years. Thus, if FIA trends in the cumulative effects analysis area continue for the next 10 years, they will not be reflected on the Chequamegon-Nicolet National Forests. The exceptions are paper birch, which decreases in the next decade in all alternatives by as much as 21% (Alternative 1), and oak which, increases in all alternatives (by as much as 20% in Alternatives 3 and 9) except Alternative 1. The projected trends for these two species are similar to FIA trends.

When comparing 1983-1996 FIA trends to the 100-year Forest vegetation composition projections, jack pine, aspen, paper birch, and balsam fir (except in Alternative 1) are projected to decline over the next 100 years in all alternatives. These species also declined in the 1983-1996 FIA analysis. Northern hardwoods and oak are projected to increase on the Forests over the next 100 years, and both are projected to increase in the cumulative effects analysis area. However, the 100-year projection indicates an increase in white pine on the Forests, while FIA data indicates a 17% decrease in white pine. Further, three species increasing in the FIA data (red pine, white spruce, and tamarack) are not expected to change on the Forests in the next 100 years.

Changes in vegetation composition for species beyond the major cover types were also considered, particularly for trees that are species of viability concern due to regeneration problems. Elm, hemlock and yellow birch were the only tree species whose growing-stock volume did not increase between 1968 and 1983 (Raile 1985). Hemlock and yellow birch were dominant trees in pre-EuroAmerican settlement forests, and are now relatively uncommon and continuing to decline. FIA data collected in 1996 for Province 212 shows that hemlock makes up only 2.8% of basal area (BA) in the maple-basswood forest type and yellow birch 2.2% (FIA 2001). Yet, an average of 21.6 million board feet (MMb) of hemlock and 14.7 MMb of yellow birch were removed annually from commercial forestlands in northern Wisconsin (Raile 1985). American elm volume declined 77% in between 1983 and 1996 due to Dutch elm disease and salvage harvests (Schmidt 1997,

using data for Northeast, Northwest, and Central FIA Units). American elm is now designated a Regional Forester Sensitive Species (RFSS) on the Forests. Projected acres of hemlock on the Forests are expected to remain the same over 10 years and 100 years. However, a number of management activities are aimed at increasing regeneration success and the continued persistence of hemlock and yellow birch ("Vegetation Management" section, Chapter 2 of Forest Plan); these Standards and Guidelines are consistent across all alternatives. Some alternatives give greater emphasis to reducing deer herbivory through MA 2B designation, which is a significant threat to hemlock persistence (Alternatives 3, 9, 4, SA, 7, 6, 5, 2, and 1, in order of favorability). Considering the declining hemlock trend and deer threat in the cumulative effects analysis area, the Forests are one of the few major land-ownerships where efforts are planned to protect existing trees, improve habitat, and modify landscape patterns to decrease the likelihood of deer herbivory. Therefore, the Forests' contribution to the continued persistence of hemlock in the cumulative effects analysis area is important.

Northern white cedar acreage decreased by 16% in northern Wisconsin between 1983 and 1996; black spruce, another predominantly lowland conifer type, decreased by 32% (Schmidt 1997). Survivorship of northern white cedar saplings in northern Wisconsin is very poor, with browsing by white-tailed deer believed to be the major threat (Rooney et al. 2002, Van Deleen 1999, Heitzman et al. 1997). Ten RFSS plants find their primary habitat in cedar swamps or mixed swamp conifers – only northern mesic hardwood forests contain more rare Forest species. Cedar swamps and mixed swamp conifers are enrolled in active timber management programs on state, county and many private lands (including those enrolled in Managed Forest Law). However, on the Forests they are classified unsuited for timber production in Alternatives 2-9 and the Selected Alternative of the Forest Plan due to impacts on regeneration and species of viability concern, hydrology concerns, and poor success of past treatments.

Understory vegetation is more difficult to assess at a regional scale. Understory vegetation was affected by turn-of-the-century logging and fires and continues to be impacted by deer herbivory and invasive plants (discussed earlier in this section). Timber stand regeneration and maintenance methods can affect understory species diversity and persistence. Naturally regenerated pine stands are more diverse than planted stands, because artificial regeneration methods often involve herbicides to eliminate or severely reduce understory species. Pine plantations cover 355,000 acres in northern Wisconsin, 61% of which is red pine (Smith 1986). Large acreages of red pine were planted in response to jack pine budworm outbreaks in the 1980s and 1990s, with red pine acreage increasing 26% between 1983 and 1996) (Schmidt 1997). Artificial regeneration is likely to increase or remain steady in the cumulative effects analysis area. On the Forests, herbicides are not used during artificial regeneration. In addition, Alternatives 2-9 and the Selected Alternative call for natural regeneration whenever feasible ("Vegetation Management" section, Chapter 2 of Forest Plan). This is emphasized more in MA 4B. Alternatives 3, 9, and 4 have at least 10% of the Forests' suited red and white pine in MA 4B, while Alternatives 7, 6, 5 and 2 have 6-4% (Alternative 1 has none). The Selected Alternative has 6% of the Forests' suited red and white pine stands allocated to MA 4B. Thus, in Alternatives 2-9 and the Selected Alternative (to a larger degree in Alternatives 3, 9 and 4), artificially regenerated pine acres are likely to be less common on the Forest compared with the cumulative effects analysis area.

The timing of logging operations also has an effect on forest understory vegetation. For example, summer logging can harm understory vegetation (Buckley et al. in press), coarse woody debris (Lloyd 2002), and advanced tree regeneration (Groot 1996). Frozen

ground logging reduces impacts to understory vegetation. Some alternatives emphasize frozen-ground logging of northern hardwoods as measured by the proportion of suited northern hardwoods that occur in MA 2B. Currently, some forest managers in the cumulative effects analysis area, such as Menomonee Tribal Enterprises and the Board of Commissioners of Public Lands, are harvesting northern hardwoods in winter due to the impacts of harvest-triggered defects on log quality. This practice is likely to increase as more northern hardwood sawlogs in the region become higher quality, and potentially, veneer quality. For a comparison of the MA 2B allocations among the alternatives, see Table 2-18.

Climate change could have a substantial effect on Northern Forests. There is speculation that, over time, oak-dominated forests may move north, wetland forests may convert to drier forest types, and boreal forests may be lost entirely in the state (WDNR 2002a).

Age class, size class, average tree diameters, and origin are all elements describing Forest structure. While trees in the 20-80 year age classes increased during the last two FIA cycles, stands of trees older than 100 years actually decreased (Schmidt 1997). This trend is likely to continue, since standard rotation age for most species is 100 years or younger. After the first decade on the Forests, acres of red oak, red pine, and white pine projected to be 100 years or older increases by a small percentage in all alternatives. After 10 decades the increase is even greater, with little variation by alternative (except in Alternative 1 which is projected to have one half as many acres of red pine older than 100 years). Although pole-sized timber is the dominant size class among commercial forestlands, sawtimber volume increased by 30% between 1983 and 1996. Similarly, the sawlog production on the Forests will also increase in alternatives between 15% and 30% in the first decade.

Only 18% of commercial timber sales on lands in private, non-industrial ownership benefit from professional forestry assistance. High-grade logging continues on a significant acreage of private forestland (WDNR 1999c). Silvicultural practices within the Forests are largely typical of those on other governmental units within the cumulative effects analysis area, with a few exceptions. Timber marking guides focus on crop trees, residual basal area, and removal of high risk and/or low vigor trees, and bole quality (WDNR Silvicultural and Forest Aesthetics Handbook, Chapter 13). On the Forests, managed northern hardwood forests will develop somewhat larger trees in some alternatives than in others. During harvest actions, the number of live reserve trees and larger class size reserve trees in managed northern hardwood stands will also be higher in some alternatives than in others. The alternatives are listed in descending order based on proportion of managed hardwoods prescribed for the larger diameter/larger reserve tree emphasis: 3, 9, 4, SA, 7, 6, 5, 2, and 1.

Most managers of commercial forestlands in the cumulative effects analysis area are now managing for smaller-sized sawlogs (less than 18 inches), as utilization standards for smaller diameter sawlogs improve at sawmills (T. Jokinen, pers. comm.). Notable exceptions include the Menomonee Tribal Enterprises, which manages the forests of the Menominee Indian Reservation, and the Board of Commissioners of Public Lands, a State agency.

Reserving snags and den trees is now a fairly common practice during timber harvest actions, although the number reserved appears to vary by ownership. The WDNR Silvicultural and Forest Aesthetics Handbook lists 2-4 snags per acre as a general rule of thumb (WDNR 2001). Industrial and private lands (not enrolled in Managed Forest Law) tend to leave fewer than 2-4 trees per acre. For the Chequamegon-Nicolet, forestwide

reserve snag Guidelines, which apply across in Alternatives 2-9 and the Selected Alternative, require up to 10 snags per acre (emphasizing the largest trees). Alternative 1 calls for 1 snag per acre (at least 12 inches in dbh) and one den tree per acre.

Forest diseases and insects are an increasing problem due to the continual introduction of Non-native species. Gypsy moth infestation is spreading in the north, and new pests such as the emerald ash borer are expected. Wildfire suppression continues with only small acreages of prescribed fire being utilized as a management or restoration tool.

Overall, Alternatives 2-9 and the Selected Alternative will result in some elements of vegetation structure and composition that are different from those of the cumulative effects analysis area and many conditions that will be similar. All alternatives (with the possible exception of Alternative 1) restore structural and species toward what is thought to be pre-EuroAmerican settlement conditions. However, Alternatives 3, 4, and 9 provide the most opportunities for: 1) increasing forest structural characteristics that tend to be missing or at low levels in today's Forests, and 2) changes in species composition that would be the most dissimilar to the management emphases and trends in the cumulative effects analysis area. Alternative 1 is likely to result in species composition and landscape patterns most similar to those of the cumulative effects area, and move the least towards historic conditions.

On the Forests, a number of opportunities occur that are largely lacking elsewhere in the cumulative effects area. These include the ability to manage for large blocks of interior northern hardwood forests, restore large acreages of pine barrens, use prescribed fire as a tool for managing pine forests, emphasize mature and late-successional stages, mimic natural disturbance processes, and designate areas with little or no timber harvest impacts. These opportunities are incorporated into Alternatives 2-9 and the Selected Alternative to varying degrees as described above.

Cumulative Effects for Non-native Invasive Species (NNIS)

From 1980 to 2000 the population of northern Wisconsin increased by 10.48% (USDA Forest Service 2003b). Population growth creates an increase in private land development for roads, housing, commercial entities, etc. Increased development, as well as increased traffic from areas that have more problems with NNIS than northern Wisconsin, contribute to the growth and spread of Non-native invasive species in the landscape surrounding the National Forest lands. This will make it very difficult to keep NNIS from spreading to National Forest lands. The long-term effect will be an increase in homogenization of biodiversity at landscape levels.

In the last few years there has been increasing interest in this issue from private environmental organizations, educational institutions, and other land management agencies. This has led to the formation of partnerships and working groups to deal with NNIS across many land ownerships. In addition, more educational materials have been created and made available to the public. The State of Wisconsin also has NNIS statutes (66.04047, and 23.22) and is in the process of updating these weed laws. Should they be adopted in their current form, more Non-native invasive plant species will be targeted for management and there will be more encouragement for state agencies and local municipalities to manage NNIS problems. The attention to this problem should help the CNNF effectively manage NNIS.

Cumulative Effects for Soils

Cumulative effects for soils are similar in all alternatives. Currently, there are actions taking place within the cumulative effects analysis area that are similar in type and amount of ground disturbance to those proposed in Alternatives 1-9 and the Selected Alternative. Some of these proposed actions would occur over acres that have previously had similar treatments, such as a thinning harvest. Existing roads, landings, and skid trails would be used to minimize new ground disturbance. Alternative 1 would have the potential to impact the most acres of soil over time. Alternative 4 would impact the least acres of soil, because fewer acres are proposed for ground-disturbing activities. However, Alternatives 1-9 and the Selected Alternative are all relatively similar in terms of the types of activities and amount of acres that are proposed for treatment (as a percentage of the CNNF land base). Activities in each action alternative indicate that no appreciable short or long-term detrimental soil disturbance would be expected. Monitoring indicates that adherence to current and proposed Land and Resource Management Plan Standards and Guidelines, site-specific design features and mitigation measures, and contract provisions would eliminate or minimize potential adverse impacts from erosion, displacement, compaction, rutting, burning, or nutrient removal. (USDA Forest Service, 1998d, p 65) Storage of soil and biomass carbon is projected to increase.

Since all Alternatives propose potential ground-disturbing activities for several future decades, it is likely that similar activities will also be proposed in future Forest Plan revisions. All proposed actions on federal lands will be subject to environmental effects analysis. Project implementation will follow site-specific design criteria, applicable research, current Land and Resource Management Plan direction, Standards & Guidelines, mitigation measures and Best Management Practices. These practices will eliminate or minimize potential adverse soil resource impacts from erosion, displacement, compaction, rutting, burning or nutrient removal. Storage of soil and biomass carbon is projected to increase. The effects of implementing Alternatives 1-9 and the Selected Alternative, when combined with the effects of past, present, and reasonably foreseeable actions, would not result in adverse cumulative effects to the quality of the soil resource or total forest ecosystem carbon storage capacity.

Cumulative Effects for Air Quality

All areas of the Chequamegon-Nicolet National Forests meet air quality standards. Compliance with state and federal air quality regulations will ensure that future forest management activities under any of the alternatives would continue to protect air resources on the Forests and not contribute to air quality degradation off the Forests. However, as local and regional populations grow the potential for adverse air quality impacts to Forest resources increases.

Landscape Patterns

Introduction

"Landscape pattern" describes the arrangement of species and communities in a natural setting. A landscape is an area of land with clusters of interacting ecosystems (Forman and Godron 1986). It is larger than a stand of trees and smaller than a region. Landscapes have three structural levels: a **matrix** (similar vegetation connected within the landscape), **patches** (isolated portions of similar vegetation within the matrix), and **corridors** (relatively narrow areas connecting patches) (Forman and Godron 1981).

A variety of methods are used to evaluate landscape patterns. One common method is patch analysis, in which patches of similar land types (or vegetation types) are measured for size, shape, and arrangement (Forman and Godron 1981). Based on soil types, topography, and natural disturbance regimes, some landscapes exhibit more patches in a greater variety than others.

Representation of various patch sizes is a key factor for ecosystem sustainability. Comparing current patch patterns to the historic landscape patterns is thought to give an indication of ecosystem sustainability. Very small patches, equivalent to a forest canopy gap, are important habitat components for species such as Canada warbler, magnolia warbler, and black-throated blue warbler (Howe et al. 1996). Large patches may improve species viability by decreasing dispersal distance and increasing the likelihood of mating (Primack 1993, SVE 2002). Greater diversity of habitat-specific species occurs as patches become larger (Primack 1993). The absence of some kinds or sizes of patches can result in the absence of some species and the functions they play in the ecosystem.

Although habitat in various seral stages across a landscape is important in providing habitat capable of supporting a diversity of species, the fragmentation of this habitat into smaller patches has potential consequences for the population viability of many plants and animals (Saunders et al. 1991). Forest interior and patch size are particularly sensitive to the spatial configuration of harvest activity (Gustafson and Crow 1999; Gustafson and Rasmussen 2002). While many species appear to require large blocks of forest to provide the interior habitat conditions in which they live, other species prefer edge habitats, or use the habitats created by natural or harvest disturbance to meet their life history requirements. If Interior Forest is defined as that area that is free from impacts on area-sensitive species associated with edges, then ideal patch size will vary; since species that are area-sensitive have varying requirements for size of interior habitat patch size. In northern Wisconsin, one of the principle mechanisms of habitat fragmentation and edge creation is through dispersing harvests throughout the forest, creating differences in structure and composition.

Current Condition

Generally, today's Forests can be characterized as having reduced patch size and complexity, a high percentage of young successional stages, and a large amount of edge habitat when compared to the estimated historic variability. (See the *Comparison of the Current Conditions with Historic Conditions for Landscape Pattern* section). Chequamegon-Nicolet National Forests' (CNNF) landscape patterns are a byproduct of management decisions, resulting in the creation of more, smaller, and simpler patches and a cumulatively more simplified and fragmented landscape (Pastor and Borschart 1990; Mladenoff and Pastor 1993). Where large patches do occur, it is usually due to special management direction in Wilderness areas or in river corridors. However, the overall effect is a uniform distribution of patches, rather than a more natural, random (or clustered) arrangement (USDA Forest Service 2000a).

The Great Lakes Ecological Assessment analysis (GLA 1997) provides data on the types of patches present in the landscape. Aspen-birch is the single most abundant cover type on the Chequamegon Forest, representing 30% of forested acres and 26% of the total acres. It is the second most abundant cover type on the Nicolet, representing 25% of forested acres and 18% of the total acres. The managed even-aged aspen stands lack the conifer component typical of naturally evolved stands.

On the Chequamegon land base, hardwood forest types are the second most abundant cover type representing 27% of forested acres and 24% of the total acres. On the Nicolet, hardwood types represent 27% of forested acres and 20% of the total acres. Hardwoods occur in a variety of patch sizes, occasionally hundreds of acres in size. Even so, smaller aspen clearcuts fragment some hardwood patches where suitable soil types occur and enough aspen exists to support regeneration.

White pine forests, hemlock forests, and lowland cedar stands are relatively scarce in the landscape, and in many mixed stands the conifer component is limited (WDNR 2002a). These conifer types make up a low percentage of overall forest makeup. For example, only 1.5% of the Chequamegon is typed as cedar, and less than 0.9% of the forest is considered old growth cedar (greater than 100 years old). Natural red pine forests are rare and decreasing as they age (WDNR 2002a). Red pine and white spruce plantations were established extensively during the first half of the 20th century.

In general, northern Wisconsin old growth forests (over 100 years old) are rare (WDNR 2002) and declining (Schmidt 1997). On the Forests, old growth stands are relatively small and well dispersed in a mosaic of younger age stands.

Fragmentation occurs when large and continuous blocks of habitat types are cut into smaller pieces and the habitat between the remaining pieces is different from the original large blocks. Table 3-20 shows existing conditions on the Chequamegon and Nicolet National Forests for selected habitat fragmentation components. These components are defined as: even-aged stands of 0-10 years of age; upland open land, which includes small upland forest openings (wildlife openings), gravel pits, and other openings; and wetland openings including sedge meadows, shrub swamps, and bogs. Other contributing features to habitat fragmentation are: open water (including lakes, ponds, streams and rivers), roads, trails, and utility corridors.

Table 3-20. Existing acreage of selected forest fragmentation components

Component	Acres
Aspen -- 0-10 years old	63,496
Jack Pine -- 0-10 years old	11,966
Red Pine -- 0-10 years old	7,747
Upland Spruce -- 0-10 years old	1,516
Pine Barrens/Oak Savannah	8,200
Other Upland Openland	25,164
Wetland Openland	148,684
Total	266,773

Small upland openings, created or maintained for wildlife game species, contribute to the overall reduction of average stand size and contribute to the fragmented nature of the landscape.

Large landscape patches increase both interior habitat and patch connectivity (Crow et al 1999) and contribute to biological diversity at all levels of biological organization (Crow et al. 1994). On the Chequamegon-Nicolet National Forests, large patches, greater than 100 acres, comprise 15% of the northern hardwood forest, 14% of upland openings/regenerating forest, and 6% of aspen. In summary, 9% of upland forest is in large patches greater than 100 acres.

In an unpublished report, Padley and McWethy (1999) compared the Chequamegon-Nicolet landscape pattern with other major land ownerships in northern Wisconsin. Patch size distribution comparisons among cover types indicate the following:

- Patch sizes in general are small, regardless of ownership—an average patch size for upland conifers is 7 acres; for aspen, 8 acres; for northern hardwoods, 19 acres; for mixed deciduous/conifer, 6 acres; and for lowland forest, 12 acres;
- On the Chequamegon-Nicolet, upland conifer patches are slightly larger than average, at 9 acres, while aspen patch sizes are slightly smaller than average, at 7 acres;
- Two cover type groups on the Chequamegon-Nicolet have patch sizes larger than average—northern hardwood patches average 30 acres, and lowland forest patches average 17 acres.

Patches of upland conifers and wetlands (especially forested wetlands) greater than 100 acres are scarce, relative to other vegetative types in northern Wisconsin. Large patches of open land are more common on private land than public land.

Current Management Direction

For National direction affecting landscape patterns see the “Current Management Direction” section under Terrestrial Ecosystem Components where the legal and administrative framework for vegetative composition, structure, and function is discussed. This framework applies to landscape pattern as well.

There are no direct references to landscape pattern in either the 1986 Chequamegon or Nicolet National Forest Plans. Nevertheless, current direction on the national forests does affect landscape pattern through resource management such as timber, wildlife habitat, and travel corridors.

The Nicolet Plan contains several goals that indirectly relate to landscape pattern.

- "Provide for diversity of plant and animal communities by working toward the desired future vegetative composition, age class and spatial distribution set forth in the plan" (**Nicolet LRMP, 21**).
- One goal states that new roads will be built, and existing roads will be upgraded (**Nicolet LRMP, 20**).
- Timber management goals speak to the percentage of proposed clear-cutting (14%), and the regeneration of aspen, jack pine and spruce/fir to achieve composition objectives (**Nicolet LRMP, 20-21**).

The Chequamegon Plan describes several goals that indirectly relate to landscape pattern.

- "Provide the greatest diversity forest wide for purposes of protecting and maintaining a variety of habitats for all plants and more than 300 species of animals" (**Chequamegon LRMP, IV-1**).
- A wildlife management goal protecting and enhancing threatened and endangered species habitat. The timber wolf is one listed species indirectly associated with aspen management (clearcutting), which is carried out in part to maintain and enhance the wolf’s primary prey (deer) (**Chequamegon LRMP, IV-2**).
- A wildlife goal managing white-tailed deer and ruffed grouse habitat also includes aspects of habitat fragmentation (clearcutting and permanent forest upland opening construction and maintenance) (**Chequamegon LRMP, IV-2**).
- Timber management goals include increased aspen production and harvest levels through clearcutting (**Chequamegon LRMP, IV-3**).

- Land adjustment goals establish a more efficient land ownership pattern through exchange, purchase, and partial acquisition. No more than 88% of the land within the proclamation boundary is to be purchased (**Chequamegon LRMP, IV-5**).
- The plan includes a goal to maintain existing roads, but does not mention new road construction or upgrading existing roads (**Chequamegon LRMP, IV-5**).

Standards and Guidelines for both plans attempt to maximize species variety by creating or maintaining wildlife habitat and combining forest types. The Chequamegon Plan's vegetation management Standard calls for "Ensuring diversity of vegetative types by providing a mix of suitable goals. Permanent openings, pioneer timber species, hardwoods, conifers, various age groups (including old growth), mast producers, den trees, wetland, and other vegetative types will be interspersed among the goals to meet diversity objectives" (**Chequamegon LRMP, IV-22**).

The Nicolet Plan's diversity Standard and Guideline states that pine and other conifer stands intermingle with stands of aspen, oak, or other mixed tree species to break up conifer stand continuity. The plan continues, "The maximum size for conifer stands will be 1,000 acres," but that "forested stands will generally be at least ten acres in size." Further, "Stand shape should blend with terrain and other natural features (biological, hydrological) to avoid artificial geometric patterns." (**Nicolet LRMP, 45**).

Nicolet Plan visual quality Standards and Guidelines (retention and partial retention) indicate: "Temporary openings may be 40 acres but are designed to appear smaller" (Nicolet LRMP, 41-2). The maximum temporary opening size will be 40 acres, except in Goal 6.2 and Goal 9.2 areas, where it will be a maximum of 25 acres (**Nicolet LRMP, 48).** Standards and Guidelines for permanent openings state, "Existing and newly constructed openings are distributed throughout the management areas. Where possible, they are well dispersed and located between contrasting timber types . . ." (**Nicolet LRMP, 64**). Designated old-growth stands are also to be "distributed throughout the Forest," with all timber types represented.

Smaller, even-aged stands are prescribed for both upland game bird areas and deeryards, averaging 20 acres or less. In deeryards even-aged cuts are distributed spatially and evenly over time (**Nicolet LRMP, 67**). Table 3-21 shows the percentage of even-aged management prescribed for each management area by each forest plan.

Table 3-21. Proportion of Even-aged Management Prescribed in each Management Area, by Forest Plan

Management Area	Chequamegon Plan	Nicolet Plan
Goal 1 (Aspen) [1]	45-85%	69%
Goal 2 (Uneven-aged Hardwoods) [2]	15-30%	33%
Goal 3 (Even-aged Hardwoods)	45-85%	75%
Goal 4 (Conifers)	55-95%	77%
Goal 6 (Semi-Primitive Non-Motorized)	25-45%	47%

[1] Most abundant management area on the Chequamegon (35% of the forest).
[2] Most abundant management area on the Nicolet (26% of the forest).

The overall management direction provided by both the Chequamegon and Nicolet 1986 Forest Plans indirectly encourage a landscape pattern dominated by small patches, with a high mixture of early-successional forest habitat managed in an even-aged manner, resulting in a highly different landscape where large patches are rare (USDA Forest Service 2000a).

Comparison of Present Conditions to Estimates of Natural Variation (Range of Natural Variability)

The Analysis of the Management Situation for Landscape Pattern contains a detailed comparison of current landscape pattern to the Range of Natural Variability (RNV). A summary is provided here.

Extensive turn of the century logging created a landscape pattern dramatically different from what existed before that time. Only small and isolated mature forest patches remained after the logging era. Since that time, as forests matured, there was a shift back towards a forested landscape. However, an extensive road system, human settlement, and forest management for timber and other goods and services modified this recovery.

In the current landscape, small patches dominate, large patches and interior conditions are rare, and some patch types such as old growth are much smaller and highly isolated. Historically common ecosystems and once-dominant species, such as hemlock, became rare, while previously uncommon species (e.g., aspen) became commonplace. This situation is well outside the historical range of natural variability for both landscape structure (size and distribution of patches) and landscape composition (mix of forest types and successional stages). This emphasis on disconnected patches impacts many species that react negatively to large amounts of forest edge or isolated stands.

Fragmentation and edge concerns are different from those found in agriculture-dominated landscapes. Although not fragmented in the same way as southern Wisconsin's isolated woodlots, Chequamegon-Nicolet National Forests are fragmented in the following ways (Mladenoff and Pastor 1993): isolation of ecosystem-type patches (such as hemlock or old growth); excessive interspersion of forest types; lack of large patches; and lack of blocks/patches of contiguous habitat conditions, including both closed-canopy forest and mostly-open savannas. Studies of forest bird species show that nest predation and competition are the most important factors limiting nest success in the northern forests. Studies found increased predation of certain species in proximity to forest edges (Fenske-Crawford and Neimi 1997; Flaspohler et al. 2001). Increased competition from generalist species can result near forest edges. Impacts on forest specialist bird species have been found in forest openings (Hamady 2000) and along aspen-mature forest edges (Mason 1995).

Where not driven by fire events, the pattern of historical natural disturbances in northern hardwood forests created a patch size distribution of 2.5-25 acres (31%), 26-250 acres (30%), 251-2500 acres (26%), and >2500 acres (13%) (Frelich and Lorimer 1991). This distribution is believed to have persisted for approximately 3,000 years prior to EuroAmerican settlement. Present day patterns are well outside of this distribution. Differences between current conditions and the range of natural variability were also noted in patch shape, adjacency relationships, and number of patches (Frelich and Lorimer 1991; Mladenoff et al. 1993; Padley and McWethy 1999)

We do not know the specific arrangement of disturbance patches in the pre-EuroAmerican settlement period, but can make some inferences based on present-day studies in Wilderness forests. Mladenoff et al (1993) compared two adjacent landscapes, the Sylvania Wilderness Area in Michigan's Upper Peninsula and the Border Lakes area in Vilas County, Wisconsin. Sylvania is an old-growth landscape, while the Border Lakes area is typical of managed, second growth regional landscapes (although it does contain several scattered old-growth patches). The study noted the following major differences:

- Patch sizes were much larger in the Sylvania Wilderness Landscape;

- The second-growth landscape had more patches, and smaller, simpler patches resulting in more edge and reduced connectivity;
- Complexity and variety of patch shapes were greater in the Sylvania Wilderness landscape;
- Repeating patterns characteristic of various landscapes have been lost. For example, the hardwoods/clearcut/swamp pattern has largely replaced the more characteristic ecological gradient of hardwoods/hemlock transitional forest/swamp. In the Border Lakes study, Mladenoff et al (1993) found that in the Sylvania Wilderness landscape hemlock stands correlated positively with lowland conifers. This characteristic relationship was lost in the second growth, managed-forest landscape. Lowlands are believed to be refugia for hemlock during dry periods (Spies and Barnes 1985; Pastor and Borschart 1990).

Other changes in landscape pattern and their implications:

- Deer are more abundant and well distributed because aspen and other early successional forest types are highly scattered across the landscape;
- There was a reduction in large blocks of contiguous habitat conditions (including closed-canopy forest and mostly-open savannas). Habitat specialists, such as the black-backed woodpecker, or area-sensitive species, such as northern goshawk, require large habitat blocks (Green 1995). Small average patch sizes negatively impact species dependent upon large areas, or species requiring specialized habitat;
- Reduced connectivity of similar habitats can result in species dispersal problems, especially when large distances or intervening unsuitable habitat between population remnants prevents movement (Wilcox and Murphy 1985, Temple 1991);
- The proportion of edge habitat has increased, resulting in increased competitive pressure for many interior bird species (Mason 1995). In addition, there are problems with predation, parasitism, physical changes, and the increased risk of invasion of Non-native invasive species (Janzen 1986; Noss and Harris 1986; Harris 1984; Flashpohler et al. 2001);
- The arrangement of habitat patches was highly altered, with upland open and regenerating forest highly interspersed in mature forest. This has negative implications for edge-sensitive bird species, many of which are negatively correlated with the proportion of upland open and regenerating forest habitat in the surrounding landscape (McRae 1995);
- Increased development within the Forest matrix led to habitat loss, permanent fragmentation, and changes in landscape composition, structure and function. One example is increased numbers of cats, raccoons and skunks associated with human developments.

Overall, the landscape structure is more simplified compared to conditions typical of the range of natural variability.

Proposed Changes and Range of Changes

In revising the Forest Plan, Management Area prescriptions were refined from those found in the 1986 plans and represented in Alternative 1 in the FEIS. For example, Alternative 1 includes Management Areas that define desired conditions, prescriptions for uneven-age northern hardwood (MA 2), and prescriptions for even-age hardwood species (MA 3). Alternatives 2-9 and the Selected Alternative allocate Management areas 2A, 2B, and 2C for uneven-aged northern hardwood and 3B and 3C for even-aged

hardwood species. The refined Management Areas developed during forest plan revision include landscape pattern in their descriptions of desired condition, as well as species composition and disturbance type and frequency. More specifically, Management Areas that emphasize larger block management include those associated with northern hardwood, Red Pine/White Pine, Oak/Pine and Open land management. These include Management Areas 2A, 2B, 3B, 4B, 8C, and 4C. (See Chapter 3 of the Forest Plan for details). Patch sizes ranges from thousands of acres in 2A, 2B, 4B, 8C and 4C, to hundreds of acres in 3B. Management Areas 1A, 1B, and 1C include smaller, simpler patches of about 10 to 40 acres in size.

In addition to addressing landscape pattern within each MA description, Management Areas were allocated to the forest with consideration for current and future availability of contiguous forest patches and connections between large patches. The number of patches greater than or equal to 20,000-acres that were created by adjoining Management Areas for uneven-aged northern hardwoods (MA 2A, 2B) with northern hardwood stands within existing/potential Wilderness (MA 5, 5B), semi-primitive non-motorized areas with low disturbance (MA 6A), and Wild and Scenic River Corridors (MA 8D) ranges from 0 to 7 patches across alternatives. See Direct and Indirect Effects below for more detail.

Direct and Indirect Effects

Effects on Landscape Pattern from Vegetation Management

A comparison of the effects of each alternative except the Selected Alternative on landscape pattern was made by L. Jay Roberts (FS contractor), Eric Gustafson (North Central Research Station), and Larry Leefers (Michigan State University) using the SPECTRUM model to optimize harvest schedules, and HARVEST, a spatially explicit timber harvest simulation model to simulate those schedules in a spatially explicit environment. The Selected Alternative was developed after the effects of the alternatives were modeled by Roberts *et al*. The following is a summary from their report (Roberts et al., unpublished manuscript).

Two landscape pattern indicators – relative mix of forest types and seral stages – were previously analyzed in the *Terrestrial Vegetation Composition* section. The landscape variables analyzed in this section are the amounts of interior and edge habitat for mature northern hardwood, mature red and white pine, and all forest types combined over 100 years (see detailed methods in Roberts et al. unpublished manuscript). The age distribution and patch characteristics of 12 different forest type classes are also analyzed. The results show differences between the alternatives with the highest and lowest levels of timber production, as well as a great deal of overlap between the intermediate alternatives in most indices.

Forest Edge and Interior

This analysis was based on 3 different assumptions regarding the penetration of edge effects into the forest (30, 90, and 300 meters), as well as the assumption that harvested openings persisted for 20 years. Roberts et al. calculated interior amounts for three different habitat categories: 1) forest (excluding all lowland and upland openings as habitat, including marshes, swamps, bogs, grasslands, wildlife openings, agricultural areas, and other openings including water, roads, and harvested openings up to 20 years old); 2) mature northern hardwood (excluding all forest types as habitat, except northern hardwood and aspen at least 80 years old assuming aspen types would convert to northern hardwood at 80 years); and 3) mature pine (excluding all forest types as habitat, except

red and white pine forest types at least 70 years old). The change in these measures of forest interior and edge habitat over time was plotted for each alternative.

Results

Alternatives 3 and 4 consistently retained more forest interior habitat than the other alternatives, while Alternatives 2, 6, and 1 had more open and edge habitat. Alternatives 2-9 increased total forest interior area over the present condition, but Alternative 1 maintained the present level. Figure 3-34, Projected Total Interior Forest, illustrates the relative ranks of these alternatives based on total forest interior habitat. While Alternatives 3 and 4 were highest in forest interior habitat, the remaining alternatives overlapped considerably over the 10 decades of simulation. Generally, Alternatives 7 and 9 ranked just below Alternatives 3 and 4. Alternative 2 was consistently lower than Alternatives 3-9, while Alternative 1 was dramatically lower than all other alternatives. All results shown are for the 90-meter edge definition, because the relative abundance of interior habitat when compared among alternatives was similar for all definitions of edge habitat (30, 90 and 300 meters).

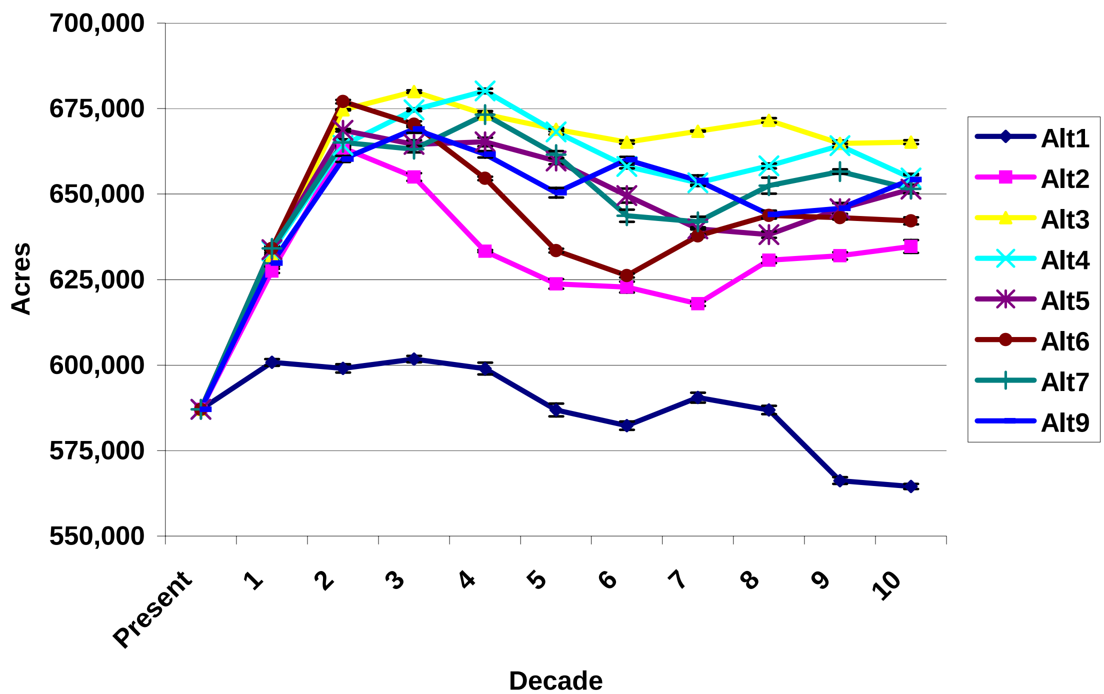

Figure 3-34. Projected Total Interior Forest

Analysis results of the mature hardwood interior forest show considerable overlap in the first 6 decades, but by the 10th decade more pronounced differences are seen. Figure 3-35, Projected Mature Northern Hardwood Interior Forest, illustrates the relative rank of alternatives based on increase in mature hardwood interior forest: 3, 4, 7, 9, 5, 6, 2, and 1 (considerably lower than all others). The rank order of alternatives is the same, and there is a large increase in the first two decades, followed by either a slow increase (Alternatives 2-9), or a plateau (Alternative 1). The large increase in hardwood interior during the first two decades likely resulted from the large number of acres in the 50-70

year age range (including the uneven-age stands) in the initial condition map. Most silvicultural treatment in northern hardwood stands is single-tree selection with some canopy gaps (varying between 25 to 40 feet in diameter), which are not considered canopy openings in this analysis. Consequently, most of the northern hardwood area simply ages and is not harvested in the model (see Figure 3-35). However, the amount of shelterwood harvesting in northern hardwoods resulted in a difference of nearly 50,000 acres between Alternatives 2 and 3 (the two alternatives showing the most contrast).

The alternatives with the most forest interior habitat are also those with the highest amount of MA 2B, 3B, and 4B (which emphasize interior forest or large patch conditions). The Selected Alternative has 250,500 acres of Alternative Management Areas (AMAs), an increase of 102,000 acres from Alternative 5. Given that AMA allocations in the Selected Alternative are similar to those for Alternatives 4 and 9, it is likely that projections for amounts of forest interior habitat for those three alternatives would be similar.

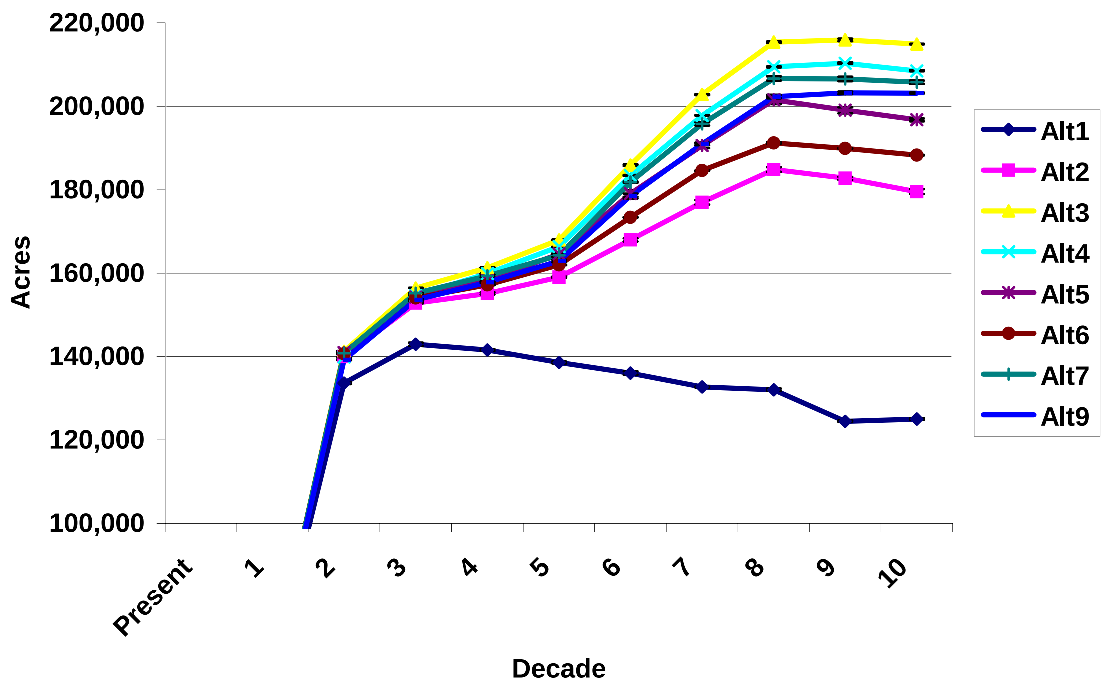

Figure 3-35. Projected Mature Northern Hardwood Interior Forest

The relative abundance of mature red and white pine interior habitat varies through time (Figure 3-36, Projected Mature Red-White Pine Interior Forest). Alternative 1 is consistently lower than the other alternatives, while Alternative 9 has the most red and white pine interior in decades 5-7, but is among the lowest at decade 10. Across all alternatives, the total acres of pine forest interior (2,000-12,000) are relatively small compared to northern hardwood (up to 220,000). There is a rapid increase in the first two decades resulting from a large amount of pine forest in the 50-70 year age class in the present condition. By the sixth decade much of the pine forest may have reached the minimum harvest age (70 years – red pine, 100 years – white pine) after which more area becomes available for harvesting and a steady decline in interior area results. Alternatives 3 and 6 have the highest area of mature red and white pine over the 10 decades of the

analysis. Given that allocations to MA 4B in the Selected Alternative are similar to those for Alternative 7, it is likely that projections for those two alternatives would be similar.

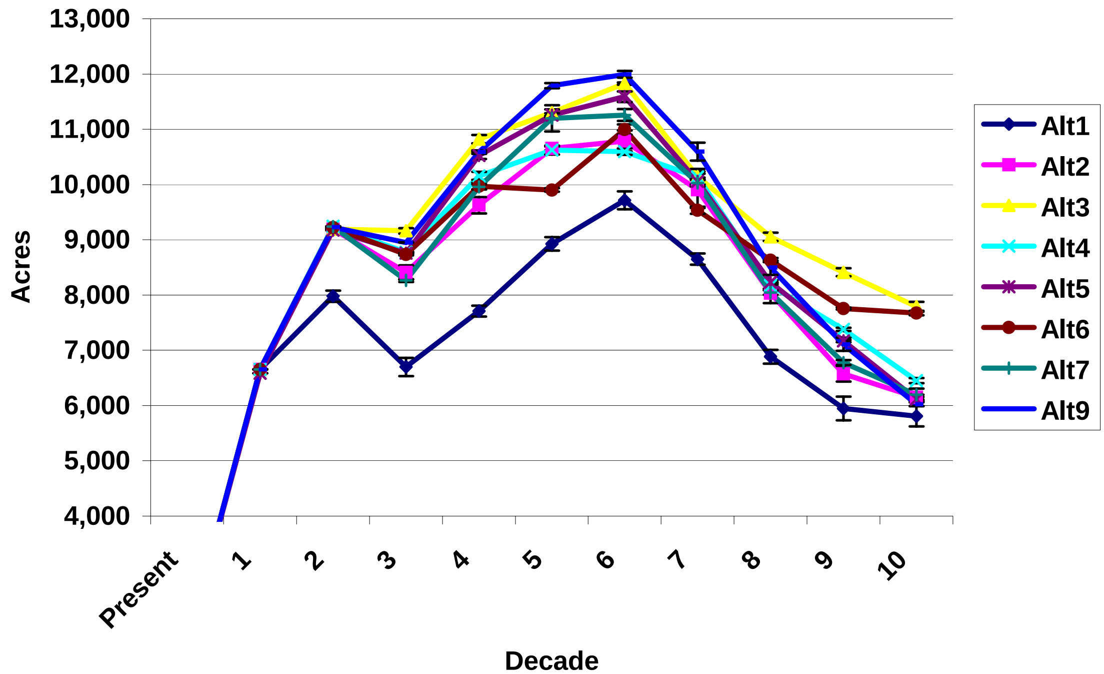

Figure 3-36. Projected Mature Red and White Pine Interior Forest

Age-class and Patch Distribution

Roberts et al. used HARVEST to calculate age class distribution and patch sizes by forest type for three age classes: regeneration (0-20 years old), immature (21-69 years old), and mature (>70 years old). The change in age class distribution and patchiness over time was plotted for each alternative. The age class distributions reflect the relative intensity of harvesting for aspen, northern hardwood, red and white pine, and jack pine. Larger areas in the mature age class indicate less cutting in previous decades. Alternatives 3, 4, 7, and 9 have the largest aspen amounts greater than 70 years old.

As noted previously, northern hardwood is managed at minimal levels in the simulation. Only Alternative 1 has visible young and regeneration acreage. The difference between age classes in Alternatives 2-9 is not visible. The large area in the young age class at the present is likely a demographic effect of an abundance of northern hardwood in the 60-80 year age range. Other forest types not actively managed show results similar to those of northern hardwoods in this analysis.

Red and white pine age class distribution does not appear to vary substantially between alternatives. Area in the regeneration age class is similar between Alternative 1 and the present condition, and slightly lower for most other alternatives. The large area in the young age class at present is likely a demographic effect of an abundance of red and white pine in the 50-70 year age range. Jack pine age class distribution varies substantially between alternatives. Alternatives 1 and 2 appear to harvest jack pine most actively (least amounts in the mature age class). Alternative 4 allows the most jack pine to reach the mature seral stage.

In addition to the HARVEST model analysis, another simulation of future landscape conditions was conducted on the Great Divide and Washburn Ranger Districts using a second model called LANDIS (L. Roberts and P. Zollner, unpublished manuscript). LANDIS (Mladenoff et al. 1996; Mladenoff and He 1999) is a spatial model of forest landscape disturbance, succession, and management. Preliminary study results are similar in pattern – that is, the rank order of the alternatives is similar to those of the HARVEST study (described above). For measures of Interior Forest, Mature Hardwood Interior Forest, Northern Hardwood patch size and total northern hardwood area, Alternatives 3, 4, 9, and 7 were consistently ranked higher, and Alternatives 1, 2, 5, and 6 were consistently ranked lower.

Although neither the HARVEST nor LANDIS models were explicitly run on the Selected Alternative, it is expected that the Selected Alternative would rank closely to Alternatives 7 and 9. The Selected Alternative improves the Forests' landscape pattern by increasing the amount of interior forest and northern hardwood patch size, and by increasing mid-late successional forest. Alternative 1 does not improve these conditions. In all measures, Alternative 3 provides the most interior forest.

Effects on Landscape Connectivity from Management Area Assignment

Two northern hardwood "large core blocks" (>50,000 acres) occur in Alternatives 3-9 and the Selected Alternative (not in Alternatives 1 or 2). They are composed of Management Areas (MA) 2B, 5B, 5, and 6A, and are therefore managed for less than 10% early-successional forest. On the Great Divide landbase, a relatively large northern hardwood-dominated "large core block" occurs across the Penokee Range (northern edge of the District) in all alternatives except 1 and 2. This block ranges from 93,000 acres in Alternative 3 to 57,000 acres in Alternative 6. It is 76,000 acres in the Selected Alternative. Similarly, on the Nicolet another large core block with a northern hardwood management emphasis extends from the Franklin-Butternut lakes area northwest to the Michigan border (the "Alvin block"). The Alvin block does not occur in Alternatives 1 and 2, and varies in size in the other alternatives from as much as 181,825 acres in Alternative 4 to as little as 61,662 acres in Alternative 7. It is 89,500 acres in the Selected Alternative. These large core blocks increase both the habitat available for species requiring large, continuous, interior northern hardwoods and, because of their arrangement on the landscape (e.g. the east-west orientation along the Penokee Range), also provide landscape connectivity by serving as travel corridors or stepping stones for species dispersing among blocks of northern hardwoods forest in the Upper Great Lakes area.

Figure 3-37 shows the total acres occurring in core blocks (including the "large core blocks")(contiguous acres in MA 2B, 5A, 5B or 6A—minimum block size of 20,000 acres). Alternative 3 has both the highest number of these core blocks (7) and the highest number of acres (530,000) in these core blocks. The Selected Alternative has 6 core blocks and the total acreage (286,400 acres) in them is less than in Alternative 3. Alternatives 4 and 9 have six and 5 core blocks, respectively, and both have greater than 250,00 acres in them (Figure 3-37). Alternatives 1 and 2 have no large core blocks.

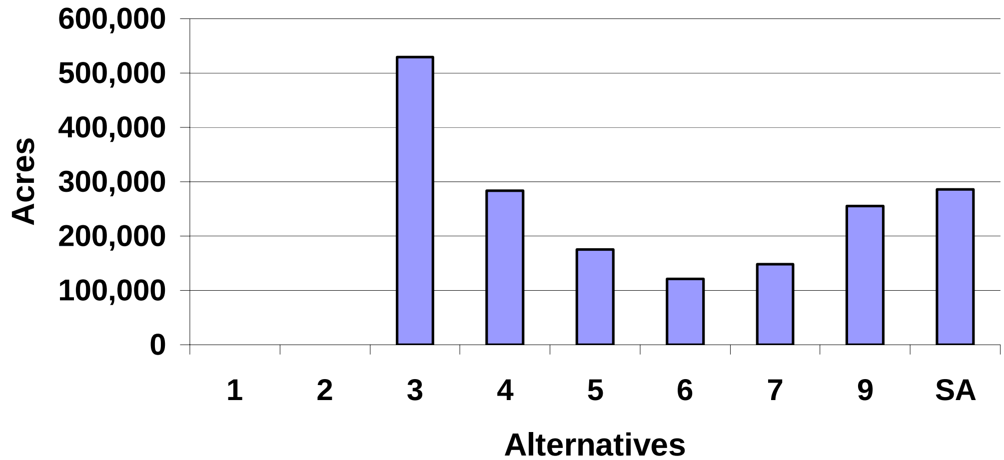

Figure 3-37. Core Northern Hardwood Blocks (minimum 20,000 acres)

The arrangement of these northern hardwood core blocks is also important to those species for which northern hardwood interior forest is considered optimal habitat, such as American marten, goshawks, red-shouldered hawks, hemlock, ginseng, etc (SVE 2002). The more interconnected the habitat, the greater the likelihood that species movement will be facilitated (Harris and Gallagher 1989; Hudson 1991; Noss 1993). Because the northern hardwood core blocks afford the most suitable habitat for a suite of species (a larger number of which are rare), it is assumed that such areas will have a lower energy cost to species that move through it (Hokit et al. 1999; McIntyre and Wiens 1999; Gardner and Gustafson in press). Further, where stepping-stones or corridors of optimal habitat are unavailable, alternative management practices (such as MA 2A and 8D) in the surrounding matrix may result in reduced "resistance" of the landscape matrix to species movement (Simberloff et al. 1992; Rickets 2001). The maps in Appendix P illustrate the arrangement of these hardwood core blocks by highlighting those northern hardwood core blocks that are greater than 20 miles long. Alternative 3 has 8 hardwood core blocks that are greater than 20 miles long, Alternative 5 has 2, and Alternative 2 has none. The Selected Alternative has 3 core blocks greater than 20 miles long. The 20-mile length was arbitrarily chosen as a landscape connectivity measure to provide a means of resolution among alternatives. The length of connective blocks that is necessary for any given species is currently receiving a great deal of attention from researchers but remains relatively unknown at this time.

After adding MA 2A (Uneven-aged Northern Hardwoods) and 8D (Wild, Scenic, and Recreational Rivers) to this analysis, the number of large Northern Hardwood-Dominated Blocks greater than 20,000 acres can be identified. Figure 3-38 shows the total acres occurring in these blocks. The numbers of northern hardwood-dominated blocks are 4 (Alternative 2), 7 (Alternatives 3, 4, 7, and 9), 5 (Alternatives 5, 6), and 6 (the Selected Alternative). These areas will be managed for at least 50% northern hardwood and no more than 20% aspen. Appendix P illustrates the arrangement of the northern hardwood-dominated blocks that have at least one dimension that is 20 miles or longer, for several of the alternatives. Alternative 3 has 7 such blocks that are over 20 miles, the Selected Alternative has 6, Alternative 5 has 5, and Alternative 2 has 2. These 6 blocks in the Selected Alternative total 477,000 acres.

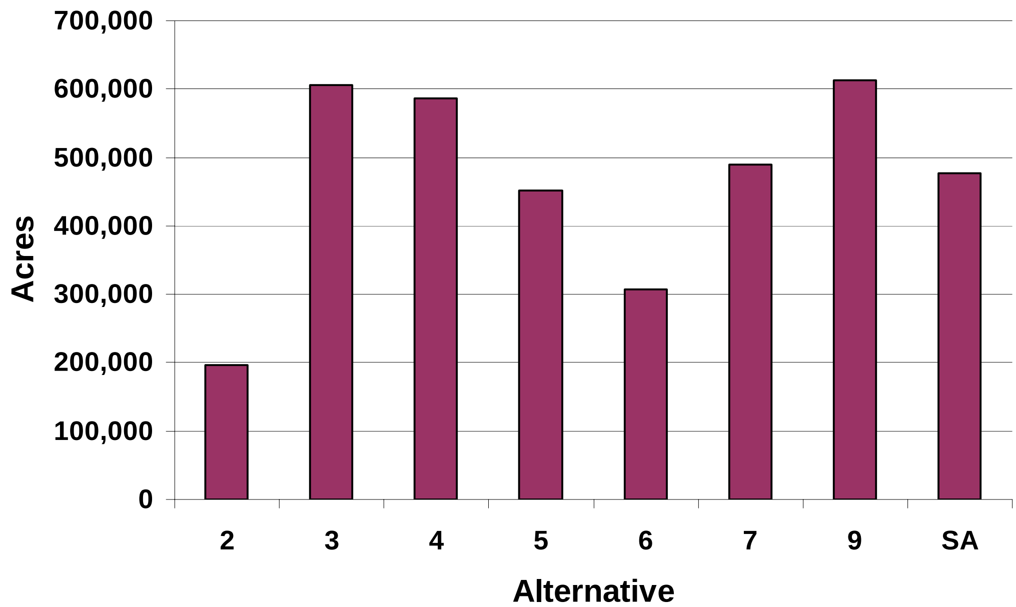

Figure 3-38. Northern Hardwood Dominated Blocks (MA 2A, 2B, 5B, 6A & 8D) Greater Than 20,000 Acres in Alternatives 2-9 and the Selected Alternative

Indirect Effects of Management Area Assignment on Landscape Pattern: Deer Herbivory

As introduced in Chapter 2, white-tailed deer browsing is affecting the establishment and survival of many species (Beals et al. 1960; Balgooyen and Waller 1995; Rooney et al. 2000, 2002) and altering ecosystem structure and composition (Van Deelen 1999; DeCalesta 1994; Frelich and Lorimer 1985; Rooney and Waller in press; Blouch 1984). Landscape pattern can strongly influence the white-tailed deer population and distribution through suitable habitat arrangement and distribution. Therefore, we can use indicators that measure landscape pattern (such as interior habitat conditions, edge habitat conditions, patch size, relative mix of forest types, relative mix of seral stages, etc.) to predict the relative effects of deer herbivory in each alternative.

The forestwide over-winter deer density goal is 16 deer per square mile (averaged across 12 deer management units). Deer populations in the North have been above goal levels for many years (although populations were near goal levels in 1992) (Rolley et al., unpublished report). In 2001 (the most recent data available), the post-hunt deer population was 40% above goal in the Northern Forest region and 30% (on average) above goal on the Forests. Weather, harvest, habitat, and feeding are the major determinants of deer population numbers. Habitat, including thermal cover and summer and winter food, is the primary way in which actions of the Forest Plan can influence deer populations. Further, as harvest and feeding factors change in response to chronic wasting disease, habitat management may become more important.

Deer habitat improvement programs in the upper Great Lakes over the last 20 years emphasized a few main elements: aspen, small upland openings, oaks (for acorn production), and dense, lowland conifer (preferably northern white cedar) for winter cover and browse (Blouch 1984; McCaffery and Creed 1969; McCaffery et al. 1974). Clearcutting shade-intolerant forest types on short rotations was viewed as favorable to

deer while selective logging of northern hardwood for sawtimber was viewed less favorably (except for the short period following selective harvest) (Blouch 1984). Summer habitat is less abundant as forests mature (WDNR 1995b). Clearcuts "scattered throughout the north" provide good winter food for deer (WDNR 1995b). Aspen was called the "region's leading deer-producing forest type" (Blouch 1984, citing work by Byelich et al. 1972), while maple, pine and balsam fir were called "poor producers of deer forage" (Blouch 1984). In reference to the conversion of aspen to these types Blouch (1984) wrote, "This deterioration of food quality in summer range may limit the size and distribution of a whitetail population in much the same manner as poor winter range." It may be possible, then, to reduce the impacts of deer herbivory in some areas, by emphasizing habitat conditions viewed as less favorable to deer. Specifically, this describes large mature blocks of northern hardwood interior forest, managed with a lower emphasis on aspen (less than 10%), and only a very small amount of upland forest openings (less than 1%). It seems improbable that such areas could substantially reduce deer densities over an entire deer management unit (average size is 450 square miles), due to the variation of habitat conditions across such large areas. However, these conditions might reduce deer densities to the goal level (of the corresponding deer management) within the mature northern hardwood forest block. At goal levels, deer populations would be roughly in the "Medium" range of density (11-19 deer per square mile as compared with "High" densities of 20 or more deer per square mile), which reduces the impact of deer herbivory on many elements of forested ecosystems (summarized in WDNR 1995b, SVE 2002).

The results of the HARVEST and LANDIS analyses described above in this section, showed that for measures of Interior Forest, Mature Hardwood Interior Forest, Northern Hardwood patch size and total northern hardwood area, Alternatives 3, 4, 9, and 7 were consistently among the higher ranked, and Alternatives 1, 2, 5, and 6 were consistently among the lower ranked. If large, hardwood "core patches" are factored in, as described in the previous section, Alternative 3 contains nearly one-third of the Forests (30%) in 6 hardwood core patches, followed by Alternatives 4 and 9, and Alternatives 5, 6, and 7. Alternatives 1 and 2 have no large hardwood core patches. Based on all the above indicators, the negative effects of deer herbivory should be reduced the most in Alternative 3, followed by Alternatives 4, 9 and 7.

Measures of Interior Forest, Mature Hardwood Interior Forest, Northern Hardwood Patch Size and total northern hardwood area are expected to be inversely related to deer herbivory pressure. HARVEST and LANDIS model projection (described earlier in the Landscape Patterns section of this chapter) showed that Alternatives 3, 4, 9 and 7 were consistently higher on these measures than Alternatives 1, 2, 5, and 6. The Selected Alternative, with an increased emphasis on Alternative Management Areas emphasizing interior forest and large patches, a greater number of core patches, and a greater number of northern hardwood-dominated blocks than Alternative 5 is likely to better mitigate the current effects of deer herbivory than Alternative 5. Nevertheless, the Selected Alternative is likely to be less effective in this regard than Alternatives 3, 4, and 9.

Effects of Road and Trail Corridors on Landscape Pattern

Dissection of landscapes by roads can have a negative effect on aspects of landscape pattern by decreasing forested core areas and increasing total edge habitat (Forman and Alexander 1998; Miller et al. 1996; Reed et al. 1996). Some roads were included in the HARVEST analysis described above. These are Maintenance Level 3, 4, and 5 roads (drivable by a passenger car), which create edge in all interior forest analyses (Roberts et

al. unpublished manuscript). See the *Effects on Landscape Pattern from Vegetation Management* section for the results of this landscape pattern analysis.

The existing CNNF road system is well developed for timber harvesting and recreation access, occupying about 2.2% of the land base. Alternative 1 would continue to provide a transportation system based on project and roads analysis needs under the structure of the 1986 Land Management Plans for the Chequamegon and Nicolet National Forests. In the first decade, Alternative 1 would propose to build 93 miles of new road, close 537 miles and decommission 327 miles of existing roads.

In Alternatives 2-9 and the Selected Alternative, closure of 780-900 miles of road and decommissioning of 1,871-1,979 miles would be needed to meet road density assignments across the Forests. However, objectives displayed in Chapter 1 of the Forest Plan call for meeting open road density goals in zero mile/square mile areas, which would require the closure of 80-230 miles of road in Alternatives 2-9 and the Selected Alternative. Other objectives call for decommissioning 40 miles of roads annually or 400 miles per decade. Project level planning would include a roads analysis process to identify specific roads for maintenance, reconstruction, closure, or decommissioning. Project level analysis would also identify needs for new road construction as well as consider Forestwide road density guidelines. The net effect of activities proposed in Alternatives 1-9 and the Selected Alternative would be a reduction in the total open road density and amount of Forest land dedicated to roads.

There is some variation in the amount of miles of ATV and ORV (4-wheel-drive) trails potentially available (see Table 3-14) in the alternatives. Alternatives 2 and 9 provide for the most miles of new trails and connectors (up to 290 miles of new trails/connectors, for a total of 574 miles forestwide). The Selected Alternative provides a maximum of 185 miles of new ATV trails and maintains the existing 284 miles of trail on the Chequamegon land base.

Cumulative Effects

Industrial and private owners hold the largest share of Wisconsin's forestland. Seventy-three percent of the land in Province 212 (the cumulative effects analysis area) is privately owned, followed by County (11%), Federal (8%), state (4%), and tribal (2.8%) (WDNR 1999c). Land parcels are smaller, development is increasing, and second homes and non-resident landowners are increasing dramatically (Schmidt 1997). Permanent fragmentation is occurring as large forest areas are converted to smaller forest patches or non-forested areas (WDNR 2000a). Human settlement is increasingly dispersed within forested areas in the cumulative effects analysis area – this condition is expected to intensify in the future (Lake States Forestry Alliance 1995).

Snetsinger and Ventura (2000) calculated a 37% decrease in forest cover from pre-EuroAmerican settlement conditions within the northern portions of Wisconsin and Minnesota. The greatest land-cover change was found on private lands, state forest, and other state lands. Less change occurred on Federal lands and Indian Reservation lands. The primary shift in composition and area pattern was from a landscape primarily made up of late-successional forest types to a landscape of primarily early-successional forest types. Previously contiguous, large tracts of vegetation (such as northern hardwood forests) became more heterogeneous, and other areas that were once diverse, mixed forests became more homogenous aspen/birch forest or nonforest lands (Snetsinger and Ventura, 2000).

In a study comparing National Forest land with private land in northwestern Wisconsin, Crow et al. (1999) found that national forest land on a morainal ecosystem (a landform left behind by the glaciers) had more complex patch shapes, but that patch shape was less complex on an outwash ecosystem (a sandy, dry landform) when compared to private land. In this analysis large natural vegetation patches were missing from private land and to some extent from public land. They further noted that the use of large harvest units and the reintroduction of fire on the Forests' outwash plains (northern half of Washburn District) restored a landscape pattern typical of the landscape prior to EuroAmerican settlement.

Padley and McWethy (1999) compared the Chequamegon-Nicolet landscape pattern with other major northern Wisconsin land ownerships. They found generally small patch sizes, with large patches mostly lacking, regardless of ownership. Chequamegon-Nicolet patch sizes, however, were larger than the average patch sizes on other ownerships. For example, northern hardwood patches on the Forests were larger on average (30 acres) than those on land under other ownerships. The Chequamegon-Nicolet has more northern hardwood patches than other ownerships, while the state of Wisconsin manages more open wetland patches than other owners, and counties own more jack pine patches. Large patches of open land are more common on private land than public land.

Large contiguous forest blocks are a desired condition in the cumulative effects analysis in several reports (WDNR 1995b, WDNR 1999c, WDNR 1995), some of which specifically mention the Chequamegon-Nicolet's unique role in providing such landscapes. This is one area where the Forests provide better opportunities than other major land-ownerships in the cumulative effects analysis area. Interior Forest, Mature Hardwood Interior Forest, Northern Hardwood patch size and total northern hardwood area were consistently higher in Alternatives 3, 4, 9, 7 and the Selected Alternative and consistently lower in Alternatives 1, 2, 5, and 6. The Selected Alternative, like Alternatives 9 and 4, will result in large areas restored to interior forest conditions, but this will not become the dominant condition of the overall Forest matrix as it would under Alternative 3.

Also, fire use and large harvest units on the Washburn District (located on the Bayfield Sand Plain subsection) resulted in landscape patterns closer to estimated historic conditions than large outwash landforms under other ownerships where the pine barrens ecosystem was once relatively common. Alternatives 3, 4, 5, 7, 9 and the Selected Alternative emphasize this management more than Alternatives 2 and 6. (Alternative 1 does not include a prescription for large block jack pine harvest). When compared to Alternative 5, the Selected Alternative proposes more MA 4B acres on the Eagle River-Florence District (in the Northern Highland Outwash Plain), which could aid in the restoration of the "pinery" that was once characteristic of this landscape.

The Selected Alternative, like Alternatives 4 and 9, is projected to result in large portions of the Forest that resemble historic landscape patterns, although not to the same degree as would Alternative 3. Over time, the Selected Alternative will result in conditions that are fundamentally distinct from the rest of the cumulative effects analysis area. The management activities associated with the Selected Alternative are likely to occur in few other areas within the cumulative effects area due to smaller ownership parcels or to other management priorities that conflict with maintaining or restoring historic landscape pattern. These conditions also provide habitat for area-sensitive species, which is an important objective for the Chequamegon-Nicolet National Forests.