Conservation Assessment

for

Pine Barrens, Oak-Pine Barrens, and Oak Barrens

USDA Forest Service, Eastern Region

September 2004

Prepared by:

Vande Water Natural Resource Services
PO Box 510
Big Rapids, MI 49307

This document was prepared to compile the published and unpublished information on the subject communities and serve as a Conservation Assessment for the Northeastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject communities, please contact the Northeastern Region of the Forest Service Threatened and Endangered Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

Table of Contents

Executive Summary 1
Community Classification System and Synonyms 2
Description of Community Types 7
Community Ecology and Environmental Conditions 10
Range of Natural Viability: Community Distribution and Conditions 13
Current Community Condition, Distribution, and Abundance 15
Population Viability 18
Potential Threats 32
Summary of Land Ownership and Existing Habitat Protection 34
Summary of Existing Management Activities 34
Past and Current Conservation Activities (Strategies) 36
Research and Monitoring 36
References 38
List of Contacts 45

Cover photographs of pine, oak-pine, and oak barrens courtesy of the Michigan Natural Features Inventory. Lansing Michigan.

Executive Summary

This Conservation Assessment addresses the biological and ecological conditions that best describe Pine Barrens, Oak-Pine Barrens, and Oak Barrens as natural community types in the Eastern Region, with specific reference to the Huron-Manistee National Forest (HMNF). It addresses the known occurrence, potential preservation, conservation, and restoration of these community types and specific plant and animal species that occur within them.

Barrens are characterized by well-drained coarse textured sandy, infertile soils derived from glacial outwash, high gravelly/sandy moraines, or lake plain systems (Curtis 1959). The vegetation consists of many xerophytes and heliophytes in a physiognomy that is commonly patchy, occurring as a mosaic of herbs, bare substrates, and stunted gnarled trees and shrubs (Homoya, 1994a). Pine barrens, with jack pine as the dominant overstory, occur in Michigan, Minnesota, Wisconsin, New York, Manitoba, and Saskatchewan (Pregitzer and Saunders 1999). Oak-pine barrens are found in Michigan, Wisconsin, Minnesota, Ontario and Manitoba (Nature Serve, 2000 cf. Cohen, 2000). Oak barrens occur in Michigan, Ohio, Indiana, Illinois, Wisconsin Minnesota, Iowa, Missouri, Kansas and Nebraska (Chapman, et al. 1995).

In Michigan pine barrens and oak-pine barrens are generally found north of the tension zone while oak barrens occur to the south. All three types occur on flat to gently rolling terrain with oak barrens also found on steep south and west facing slopes (Cohen 2001). All three communities are closely aligned to soils that are characteristically droughty, typically low in nutrients, and low moisture holding capacity. Pine, oak-pine, and oak barrens are all considered fire-dependent or fire dominated community types. Fire frequency in these ecosystems typically ranged from 0-38 year intervals (Cleland 2002 cf. HMNF 2003a); with the most open areas likely burning in successive years (Corner per comm. cf. HMNF 2003a).

In an unaltered condition barrens support a diverse flora including numerous species that are characteristic of dry prairies. A number of plants and animal species characteristic of barrens ecosystems were reduced in frequency of occurrence and density as these communities became closed canopy forests. This report addresses thirteen plant and animal species that are considered indicators of either pine, oak-pine, or oak barrens community types in the HMNF including; Alleghany plum (Prunus alleghaniensis var. davisii), pale agoseris (Agoseris glauca), Hill's thistle (Cirsium hillii), rough fescue (Festuca scabrella), dusted skipper (Atrytonopsis hianna), frosted elfin (Incisalia irus), ottoe skipper (Hesperia ottoe), persius duskywing (Erynnis persius), phlox moth (Schinia Indiana), regal fritillary (Speyeria idalia), southern grizzled skipper (Pyrgus wyandot), Sprague's pygarctia (Pygarctia spraguei), and Great Plains spittlebug (Lepyronia gibbosa).

Pine, oak-pine, and oak barrens community types have greatly declined following European settlement (Comer 1996, Cohen 2000, Cohen 2001, Chapman, et al. 1995). The

majority of the historic barrens sites have either been destroyed through land conversion or are in a degraded state as a result of plant succession to closed canopy forests due to fire suppression (Chapman, et al. 1995).

There are twelve documented pine barrens remaining in Michigan, totaling approximately 1,200 acres, with one 30-acre site in the HMNF (HMNF 2003b). Sixteen oak-pine barrens occurrences are currently documented in Michigan, totaling approximately 3,534 acres (HMNF 2003b). Four of these are in the HMNF, totaling approximately 300 acres (HMNF 2003b). There are eleven oak barrens currently documented in Michigan, but none have been identified in the HMNF (HMNF 2003b).

The rangewide decline in the acreage of pine, oak-pine, and oak barrens has brought into question the long term viability of these ecosystems and, in particular, numerous rare plant and animal species that are associated with them (Bacone, et al. 1994, Chapman, et al. 1995, Comer 1996, Cohen 2000, Cohen 2001, Haney, and Apfelbaum. 1995, Nuzzo, V.A. 1985). However, restoration of some barrens community types have met with some success (Bacone, et al., 1994, McCarty, 1993). In order to restore and maintain the mosaic landscape typical of pine, oak-pine, and oak barrens, on a large scale public managers will need to focus on developing land use plans that incorporate management practices such as timber harvesting and prescribed fire at various intervals and intensities.

Community Classification and Synonyms

Debate continues among ecologists concerning the application of the term “savanna” or “barren” to describe ecosystems that support scattered trees with an understory dominated by forbs and grasses. Barrens and savannas are structurally and floristically intermediate between prairie and oak forest and are characterized by scattered overstory trees and a fairly open canopy (Minc and Albert 1990). McPherson (1997) considers the term “barrens” to be synonymous with “savanna” in contemporary usage. Early writers did not use the term savanna to refer to these intermediate plant communities (Dyksterhuis 1957, Hutchinson et al. 1986, Nelson 1987 cf. Heikens and Roberstson 1994). Originally this term was used to designate xeric grasslands with scattered trees in tropical and subtropical climates (Dyksterhuis 1957 cf. Heikens and Roberstson 1994). However, in the 1950’s, the definition of savanna was expanded to include plant communities in temperate regions (Oosting 1956, Odum 1959, Curtis 1959 cf. Heikens and Roberstson 1994). Curtis (1959) recognized both terms, indicating that savannas north and south of the tension line in Wisconsin supported several distinct community types including, oak openings, scrub oak barrens, jack pine barrens, brush prairies, sand barrens, Hill’s oak (*Quercus ellipsoidalis*), and cedar glades. He defined barrens as “a depauperate plant community with either a low total coverage or with stunted individuals of species which elsewhere reach considerable size.” Curtis (1959) viewed plant communities as a “vegetational continuum” whose floristic composition gradually changes along an environmental gradient. Savannas in Wisconsin were considered to be part of the prairie-forest floristic province, supporting elements of both prairies and forests.

Homoya (1994a,b) contends that it is appropriate to recognize barrens as distinct community types, and that the literature is resplendent with the use of the term. He indicates that the literature reveals a consistent suite of characteristics that distinguish barrens environments. These characteristics emphasize xeric and infertile edaphic conditions, a distinctive biota, and vegetation consisting of many xerophytes and heliophytes in a physiognomy that is commonly patchy, occurring as a mosaic of herbs, bare substrate, and stunted, gnarled trees and shrubs. Heikens and Robertson (1994) also indicate that many of the early writers distinguished among forest, prairie, and barrens, and Hutchison (1994) suggests that barrens is a legitimate name for a community type distinct from forest and prairie. When addressing barrens community types occurring in the Mark Twain, Hoosier, and Shawnee National Forests, Olson (2002) characterized them as supporting canopy trees tolerant of xeric conditions, having a stunted, open-grown appearance, and a predominance of native warm-season grasses and prairie forbs. Based on a review of the literature (Homoya 1994a, Hutchison 1994, Anderson and Bowles 1999, Will-Wolf and Stearn 1999, Forman et al. 1979) it appears prudent to recognize barrens as distinct communities, some of which do occur within the savanna physiognomic feature and clearly display a vegetational continuum with prairie and forest.

Numerous barrens, savannas, and prairie complexes have been characterized in Region 9 (R9) (Figure 1) including, pine, oak-pine, oak, shale, sand, pine plains, cedar glade, chert, limestone, bedrock, serpentine, sandstone, siltstone, gravel, clay, glade, alvar, dwarf pine plains, dwarf pine ridge, pitch pine-scrub, pitch pine-heath, post oak-blackjack, boreal heath, and oak openings. This report focuses on pine, oak-pine, and oak barrens.

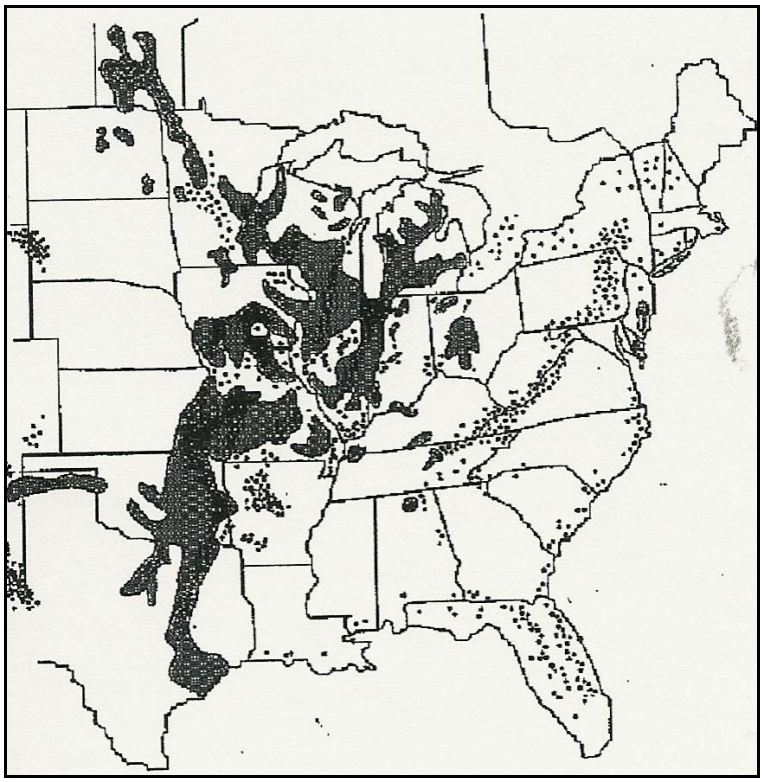

Figure 1. Approximate distribution of oak savanna, barrens, and prairie complexes in eastern United States. (Haney and Apfelbaum 1993 adapted from Nuzzo 1986)

Pine Barrens:

Pine barrens support a predominant overstory of scattered stunted trees, primarily jack pine (*Pinus banksiana*), and an understory of grasses and forbs tolerant of relatively xeric conditions. This community type occurs in Michigan, Minnesota, Wisconsin, New York, Manitoba, and Saskatchewan (Pregitzer and Saunders 1999); however, Michigan and Wisconsin are the historical centers for the occurrence of the community type dominated by jack pine. In New York the barrens type with an overstory of jack pine is classified as sandstone pavement barrens, and occurs in very shallow soils over sandstone bedrock (Edinger et al. 2002, Reschke 1990). This community type supports a relatively similar ground flora to pine barrens in the Great Lakes region. Though similar in structure, the pine barrens of New Jersey support a predominant overstory of pitch pine (*Pinus rigida*). Several other R9 states support community types that have a dominant overstory of pitch pine including Pennsylvania, New York, Vermont, Connecticut, Massachusetts, Maine, and Rhode Island.

In Michigan, communities similar to pine barrens include dry sand prairie, oak-pine barrens, oak barrens, jack pine-oak forest, and Great Lakes barrens (Comer 1996).

Additional classification: (Comer 1996, Nature Serve 2003)

- Michigan Natural Features Inventory (MNFI) Presettlement Vegetation: 333 - pine barren.
- Michigan Department of Natural Resources (MDNR): G-grass, J0 - jack pine <100 trees/acre.
- Michigan Resources Information Systems (MIRIS): 31, 33 - open land.
- The Nature Conservancy National Classification: Code; Alliance; Association; Common Name.

  V.A.6.N.f.5.; *Pinus banksiana* - (*Pinus resinosa*) – (*Quercus ellipsoidalis*) / *Carex pensylvanica*
  Wooded Herbaceous Vegetation; Jack Pine – Red Pine – (Northern Pin Oak) / Pennsylvania Sedge

  V.A.6.N.f.5.; *Pinus banksiana* - (*Pinus resinosa*) – (*Quercus ellipsoidalis*) / Schizachyrium scoparium - Prairie Forbs Wooded Herbaceous Vegetation
  Jack Pine / Prairie Forbs Barrens
  Jack Pine - (Northern Pin Oak) / Little Bluestem - Prairie Forbs Wooded Herbaceous Vegetation

<u>Oak-Pine Barrens</u>:

Oak-pine barrens range from dense thickets of brush and understory scrub oak and pine situated amongst grassland, to park-like open woods of widely spaced mature oak and pines with virtually no shrub or sub-canopy layer above the open forb and graminoid understory (Cohen 2000, Chapman et al. 1995). This community type occurs in Michigan, Wisconsin, Minnesota, Ontario, and Manitoba. The general physiognomy fits the vegetational continuum concept expounded by Curtis (1959), with oak-pine barrens grading into prairie on one front and dry oak forest on the other.

Similar communities in Michigan include bur oak plains, dry sand prairie, dry southern forest, dry northern forest, Great Lakes barrens, lakeplain oak openings, oak openings, oak barrens, and pine barrens (Cohen 2000).

Additional Classifications: (Cohen 2000)

- Michigan Natural Features Inventory Presettlement Vegetation: Oak-Pine Barren
- Michigan Department of Natural Resources: G- grass and O0, W0, R0, or J0- Oak White Pine, Red Pine or Jack Pine with <100 trees per acre.
- Michigan Resource Information Systems: 33 (Pine or Oak Opening), 412 (Central Hardwood), 4122 (White Oak), 4123 (Black Oak), 4129 (Other Oak), 421 (Pine), 4210 (Unidentified Pine), 4211 (White Pine), 4212 (Red Pine), and 4213 (Jack Pine)
- The Nature Conservancy National Classification: Code; Alliance; Association; Common Name.

  V.A.6.N.f.; *Pinus strobus-Quercus (alba, rubra*)

  Wooded Herbaceous Alliance; *Pinus strobus-Quercus alba*-(*Quercus velutina*) / *Andropogon gerardii*

  Wooded Herbaceous Vegetation; Jack Pine / Prairie Forbs Barrens

  V.A.6.N.f.; *Pinus banksiana*-(Pinus resinosa)

  Wooded Herbaceous Alliance; *Pinus banksiana*-(*Quercus ellipsoidalis*) / *Schizachyrium scoparium*-Prairie Forbs

  Wooded Herbaceous Vegetation; Jack Pine / Prairie Forbs Barrens

  V.A.6.N.f.; *Pinus strobus-Quercus (alba, rubra*)

  Wooded Alliance; *Pinus strobus-Quercus rubra* / *Danthonia spicata*

  Acid Bedrock Wooded Herbaceous Vegetation

  II.C.3.N.a.; *Pinus strobus-Quercus (alba, ellipsoidalis, rubra, velutina*)

  Woodland Alliance; *Pinus strobus-Pinus resinosa-Quercus (ellipsoidalis, rubra) / Juniperus communis*

  Rocky Woodland

<u>Oak Barrens</u>:

Oak barrens are structurally similar to oak-pine barrens with the exception that pine is not a significant feature in the overstory. This community type occurs primarily in the

prairie-forest transition region of the Midwest. Black oak barrens occur south of the tension zone from southern Michigan, southern Wisconsin, and southeastern Minnesota, south to the glaciated portions of Ohio, Illinois, and Indiana, and westward to the glaciated regions of Iowa, Missouri, Kansas, and Nebraska. Bur oak-northern pin oak barrens occur in central and western Minnesota and perhaps west-central Wisconsin (Chapman et al. 1995). Based on field observations, Haney and Apfelbaum (1995) divided the Great Lakes region dry sand savanna into northern and eastern sand savanna. Northern sand savanna in the northern and western Great Lakes support Hill's and Hill's oak hybrids, with jack pine present in the north. In the southern and eastern parts of the region, eastern sand savanna usually has black oak as the characteristic tree species, with Hill's oak absent or a minor component. Oak openings in Michigan and Wisconsin are somewhat similar to the aforementioned types; however, they typically occur on more fertile soils and under normal disturbance regimes support fewer shrubs. Latrobe (1835 cf. Anderson and Bowles 1999) described oak openings of Michigan and Illinois as having rich vegetable soils. In Michigan, the oak barrens community type typically occurs in the driest landscapes (Cohen 2001).

In Michigan, similar communities include bur oak plains, dry sand prairie, dry southern forest, lakeplain oak openings, oak openings, oak-pine barrens, and pine barrens (Cohen 2001).

Additional Classifications Applicable to Michigan: (Cohen 2001)

- Michigan Natural Features Inventory *Circa* 1800 Vegetation: Black Oak Barren and Mixed Oak Savanna
- Michigan Department of Natural Resources: G- grass and O0-oak <100 trees per acre.
- Michigan Resource Information Systems: 33 (Pine or Oak Opening), 412 (Central Hardwood), 4122 (White Oak), 4123 (Black Oak), 4129 (Other Oak),
- The Nature Conservancy National Classification: Code; Alliance; Association; Common Name.

  II.B.2.N.a.12; *Quercus alba* - (*Quercus velutina*)
  Woodland Alliance; *Quercus velutina*-(*Quercus ellipsoidalis*)-*Quercus alba/Deschampsia flexuosa*
  Woodland; Black Oak - Northern Pin Oak / Common Hairgrass Woodland

  V.A.6.N.c.3.; *Quercus velutina* - (*Quercus ellipsoidalis*)
  Wooded Herbaceous Alliance; *Quercus velutina* - (*Quercus alba*) - *Quercus ellipsoidalis*/*Schizachyrium scoparium* - *Lupinus perennis*
  Wooded Herbaceous Vegetation; Black Oak/Lupine Barrens

Description of Community Types

<u>Pine Barrens</u>:

The pine barrens community type is characterized by a predominance of grasses, forbs, and shrubs (Curtis 1959), with stunted jack pine, red pine (*Pinus resinosa*), white pine (*P. strobus*), northern pin oak, black cherry (*Prunus serotina*), and aspen (*Populus* spp.). It typically consists of a mosaic of sparse to dense woody vegetation juxtaposed to openings. These openings are quite often ice-block depressions sites or frost pockets, which typically support prairie vegetation rather than forests. In Wisconsin, frost pockets, caused by the pooling of cold air in depressions, serve as refuges for species that need open habitats (Vora 1993). The diameter of these openings is typically two to three times the height of the highest hill in the rim of hills surrounding the depression (Vora 1993).

Although jack pine is generally the predominant tree species, Vogl (1970) and Curtis (1959) noted that red pine was also an important super canopy tree within this community type. Macrofossil evidence suggests that jack pine reached Upper Michigan before red pine and dominated the early postglacial pine forests within the central and southern parts of the Great Lakes region (Critchfield 1985 cf. Pregitzer and Saunders 1999). Selective logging of red pine was a significant factor leading to the dominance of jack pine in some barrens. Fire is a key element to the maintenance of pine barrens ecosystems. Jack pine often produces both serotinous and non-serotinous cones in barrens, and Heinselman (1981) speculated that the serotinous characteristic was a direct adaptation to fire.

Curtis (1959) recognized one pine barrens type in Wisconsin, but work by Vogl (1974 cf. Drake and Faber-Langendon 1994) distinguished two types in northern Wisconsin, one with a ground layer of many prairie species and one with more shrubby species. Drake and Faber-Langendon (1994) reexamined data collected by Curtis using multivariate analysis and determined that the pine barrens was comprised of five subtypes; jack-pine oak sparse woodland, jack pine-oak woodland, jack pine forest, Hill's oak forest, and aspen forest. Jack pine was the leading dominant in the overstory of three of these subtypes, while pin oak dominated one. Basal area and canopy cover ranged from 14.1 m^2 ha^{-1} (512 stems ha^{-1}) and 34%, respectively, in jack pine-oak sparse woodland, to 25.5 m^2 ha^{-1} (730 stems per ha^{-1}) and 54%, respectively, in the jack pine forest (Pregitzer and Saunders 1999).

In his studies of pine barrens at Crex Meadows in western Wisconsin, Vogl (1961 cf. Comer 1996) estimated that there were 20 trees greater than 15 cm (6 in) in diameter per ha, which translates to an average distance between trees of 24 m (65ft). Trees in this community had typical open-grown shapes. Zimmerman (1956 cf. Comer 1996) reported that the tallest tree in his 50 study sites was 16 m (52 ft) and the average tree height was only 8 m (26 ft); however, logging may have resulted in the tallest trees to be removed. In his analysis of the General Land Office surveys conducted in western Wisconsin, Vogl (1961 cf. Comer 1996) found that the average diameter of *Pinus banksiana* and *P. resinosa* was 25 cm (10 in) and 50 cm (20 in), respectively. He described the pine barrens as landscapes with localized, dense stands of even aged jack pine and scattered, towering red pines (1970 cf. Pregitzer and Saunders 1999).

Prior to Euro-American settlement many pine barrens in Wisconsin were diverse; some resembled a pine savanna with mature red pine occurring in densities of two to eight trees

per acre. Early logging eliminated the mature trees and severe, repeated fires, along with more cutting and land-clearing, removed the seedlings and remaining red pine seed sources. Brown (1950 cf. Curtis 1959) compared conditions in pine barrens in Adams County in 1851 to present day by using information in surveyor's records, and found that tree densities had increased tremendously from 2 to 8 trees per acre to 160 to 250 trees per acre, respectively. This clearly illustrates pathway succession in Brown's study area that is primarily the result of fire suppression. Interestingly, he found almost no change in composition, with jack pine, Hill's oak, and bur oak having almost exactly the same relative representation in the dense forest as they had in the savanna (Brown 1950 cf. Curtis 1959). Curtis (1959) indicates that most of the pine barrens of Wisconsin have undergone similar density changes and their place is now taken by dense jack pine forests.

*Pine barrens in the northern Lower and Upper Peninsulas of Michigan, as well as other barrens in the region, support a mixture of plant species with affinities for either dry tall grass prairie or northern pine-dominated forest (Comer 1996). The principal shrub and herbaceous components encountered in pine barrens in Michigan include lowbush blueberry (*Vaccinium angustifolium*), sweet fern (*Comptonia peregrina*), sand cherry (*Prunus pumila*), prairie willow (*Salix humilis*), hazelnuts (*Corylus spp.*), poverty grass (*Danthonia spicata*), little bluestem (*Schizachyrium scoparium*), and Pennsylvania sedge (*Carex pensylvanica*) (Comer 1996). Other low shrubs, herbs, and forbs whose occurrence varies among locations include big bluestem (*Andropogon gerardii*), wrinkled hair grass (*Deschampsia flexuosa*), bird's foot violet (*Viola pedata*), prairie heart-leaved aster (*Aster oolentangiensis*), Hill's thistle (*Cirsium hillii*), June grass (*Koeleria macrantha*), rough blazing star (*Liatris aspera*), prairie cinquefoil (*Potentilla arguta*), and needle grass (*Stipa spartea*) (Comer 1996).*

<u>Oak-Pine Barrens</u>:

The canopy layer of oak-pine barrens generally varies from 5% to 60% cover (Chapman et al. 1989 cf. Cohen 2001) and is dominated or co-dominated by white oak (*Quercus alba*), black oak (*Quercus velutina*), northern pin oak (*Quercus ellipsoidalis*), bur oak (*Quercus macrocarpa*), white pine (*Pinus strobus*), red pine, and jack pine. Examination of the 1838 General Land Office survey records for portions of the Manistee National Forest indicates that oak-pine barrens were dominated by white pine (37%) and white oak (37%) at 2.79 trees per acre; however, there were also significant amounts of black oak (21%) at 1.58 trees per acre (Rabe et al. 1993).

Characteristic shrubs inhabiting oak-pine barrens in Michigan include serviceberry (*Amelanchier* spp.), bearberry (*Arctostaphylos uva-ursi*), New Jersey tea (*Ceonothus americanus*), sweetfern, American hazelnut (*Corylus americana*), dogwood (*Cornus* spp.), beaked hazelnut (*Corylus cornuta*), wintergreen (*Gaultheria procumbens*), huckleberry (*Gaylussacia baccata*), wild plum (*Prunus americana*), choke cherry (*Prunus virginiana*), sand cherry, dwarf chinkapin oak (*Quercus prinoides*), pasture rose

(*Rosa carolina*), northern dewberry (*Rubus flagellaris*), prairie willow, and low sweet blueberry. Common species in the ground layer include little bluestem, big bluestem, Pennsylvania sedge, prairie heart-leaved aster, false foxglove (*Aureolaria* spp.), tickseed (*Coreopsis lanceolata*), poverty grass, wrinkled hair grass, flowering spurge (*Euphorbia corollata*), divaricate sunflower (*Helianthus divaricata*), June grass (*Koeleria macrantha*), dwarf dandelion (*Krigia biflora*), white pea (*Lathyrus ochroleucus*), hairy lespedeza (*Lespedeza hirta*), dwarf blazing star (*Liatris cylindrica*), wild lupine (*Lupinus perennis*), wild bergamot (*Monarda fistulosa*), wood betony (*Pedicularis canadensis*), and needle grass (Cohen 2000).

Oak Barrens:

Oak barrens have an overstory that ranges from a sparse or scattered canopy (5 to 30%, sometimes termed a savanna physiognomy) with a ground layer that may vary from open, herbaceous dominated to scrub oak dominated, to a more closed canopy (30 to 80%, sometimes termed a woodland physiognomy). The canopy layer is dominated by black oak, northern pin oak, bur oak, or black jack oak (*Quercus marilandica*) (Chapman et al. 1995). White oak often occurs in the overstory in the eastern range, but is seldom dominant, except in woodland conditions. Other canopy species include red maple (*Acer rubrum*), black cherry, big tooth aspen (*Populus grandidentata*), trembling aspen (*Populus tremuloides*), and northern pin oak. Prevalent subcanopy species are hickory (*Carya* spp.), dogwood (*Cornus* sp.), American hazelnut, cherries (*Prunus* spp.), and sassafras (*Sassafras albidum*).

Characteristic shrubs of oak barrens in Michigan include serviceberry, bearberry, New Jersey tea, sweetfern, American and beaked hazelnut, dogwood, hawthorn (*Crategus* spp.), wintergreen, huckleberry, wild plum, choke cherry, dwarf chinkapin oak, shining sumac (*Rhus copallina*), pasture rose, northern dewberry, prairie willow, and low sweet blueberry. Common species in the ground layer include little bluestem, big bluestem, Pennsylvania sedge, prairie heart-leaved aster, false foxglove, tickseed, poverty grass, wrinkled hair grass, flowering spurge, divaricate sunflower, June grass, dwarf dandelion, white pea, hairy lespedeza, dwarf blazing star, wild lupine, wild bergamot, wood betony, panic grass (*Panicum implicatum*), goatsrue (*Tephrosia virginiana*), and needle grass (Cohen 2001).

In Minnesota, the dry oak savanna barrens subtype supports a scattered canopy (10 to 70%), short (15 to 35 feet) open grown bur oak and sometimes northern pin oak, and a patchy herbaceous ground layer comprised mostly of prairie grasses, forbs, and bare soil. Oak barrens in Wisconsin are overwhelming dominated by black oak with an understory supporting a variety of prairie species. The oak openings community type is similar in structure and species composition but historically occurred on mesic sites (Curtis 1959). Curtis (1959) described it as an oak-dominated savanna community with less than 50% tree canopy. The few extant remnants are mostly on drier sites, with the mesic and wet-mesic openings almost totally destroyed by land conversion and fire.

Community Ecology and Environmental Conditions

Pine Barrens:

Based on a review of HMNF barrens location maps and regional landscape maps developed by Albert (1995), the principal area supporting pine barrens in Michigan is north of the tension zone in the Newaygo Outwash Plain (NOP) (Subsection VII.3) and Highplains (Subsection VII.2) landscape feature. Pine barrens became established in areas with a continental climate. Summers are typically short and warm to cool with average July temperatures of 13-22 °C. Winters are cold with average January temperatures of -29 to -4 °C. Annual precipitation averages 250 to 1,400 mm (usually 380-890 mm) (Pregitzer and Saunders 1999). The growing season averages 50-173 frost-free days (commonly 80-120 days) (Pregitzer and Saunders 1999). Jack pine barrens often occur on pitted outwash plains that have coarse-textured, rapidly drained acidic soils (Stern and Buell 195, Curtis 1959, cf. Pregitzer and Saunders 1999). For example, soils of Michigan's Yellow Dog Barrens in the Upper Peninsula occur on glacial outwash plains that are sorted, well-drained medium sands (more than 95% sand by weight) (Pregitzer and Barnes 1984 cf. Pregitzer and Saunders 1999). Almendinger (1990, cf. Pregitzer and Saunders 1999) determined that, in Minnesota, soil organic matter was inversely related to the length of time that jack pine had dominated the site. According to radiocarbon dating of stratified samples of lake sediment, sites occupied by jack pine longer than 1,300 years have <2.2% organic matter in the surface horizon of the mineral soil. The decrease in soil organic matter with time probably is related to the frequency and intensity of wildfire, with the jack pine forest burning more intensely than other vegetation types. Vogl (1970) suggests that the size of individual barrens in northern Wisconsin appears to be controlled not only by the extent of sandy soils, but by the nature of the terrain. Large tracts are usually associated with level, gentle rolling, or undulating topography that permits the unrestricted spread of fires (Curtis 1959 cf. Vogl 1970).

In New Brunswick, Maclean and Wein (1978 cf. Pregitzer and Saunders 1999) indicated that biomass appeared to increase faster in jack pine stands relative to deciduous stands until age 50 years. Although in many forest ecosystems the relative percentage of biomass in the understory declines following crown closure, barrens ecosystems retain a high proportion of productivity in the herbaceous and shrub layers. A factor contributing to the dominance of lower and midcanopy strata in pine barrens is the ability of common species of the ground flora to grow relatively quickly after fire, which slows the accumulation of biomass in the pine overstory. Thus, the percentage of macronutrients in the understory is expected to be relatively high in pine barrens. Even in well-stocked, 57-year old jack pine forests, up to 30% of some macronutrients were found in the understory (Maclean and Wein 1978 cf. Pregitzer and Saunders 1999). Availability of nitrogen may be a limiting factor in vegetative reproductive growth in this community type. Jack pine conserves nutrients by incorporating relatively low amounts into its biomass. Retranslocation and subsequent mobilization of nutrients within the tree may be important methods of nutrient conservation. Fire mobilizes nitrogen that is otherwise unavailable (Pregitzer and Saunders 1999).

Heinselman (1981 cf. Vora 1993) suggested that pine forests on dry sites were historically subject to light to moderate surface fires, probably at intervals of 20 to 40 years, which killed trees less than 30 to 40 years old. High intensity fires may have killed patches of mature pine every 100 to 200 years. This created a patchwork of openings with scattered old trees interspersed with even-aged stands of younger pines. Vogl's studies in northern Wisconsin showed that the understory is well adapted to frequent fire, but the trees are not, and that infrequent fire favored red pine over jack pine (1970 cf. Vora 1993). Fires occurring more frequently than 20 to 40-year intervals would promote a more vigorous understory and reduce reseeding of jack pine. In the absence of fire, oaks, especially northern pin oak, become a common part of the canopy.

Variation in plant communities throughout the range of pine barrens is highly dependent upon site topography, fire frequency, soil differences, and surrounding plant communities. Curtis's (1959 cf. Vogl 1970) work in Wisconsin indicated that the barrens composition is variable, with each region affected by local floral constituents from the surrounding vegetation types. However, throughout the range of the jack pine dominated pine barrens, the suite ground flora species is generally quite similar.

The suppression of fire has been considered the principal factor resulting in a shift in species richness and frequency of occurrence. Shrubby species, which represent up to 30% of the species present in northern dry communities, also become more prevalent in the absence of fire (Chequamegon National Forest 1993 cf. Pregitzer and Saunders 1999). In the absence of fire Pennsylvania sedge can become a dominant ground layer and greatly reduce herbaceous species diversity (Cope 1992 cf. Comer 1997).

Vogl's (1970) studies in central and northern Wisconsin pine barrens suggest that fire, soils, and topography are equally important factors that dictate the occurrence of pine barrens. His work showed that even when fire was reintroduced in areas where it had been absent for 30 or more years, the changes in species composition were not striking. Vegetation responses often appeared to be as much a reaction to canopy opening or removal as to the direct effects of fire (Buell and Cantlon 1953 cf. Vogl 1970). In general, it appears that fire produces fewer changes and is less essential in northern Wisconsin pine barrens than in prairie and prairie savannas (Vogl 1970).

Oak-Pine Barrens:

In Michigan, the principal area supporting oak-pine barrens is north of the tension zone in the NOP landscape feature. This landscape has a growing season that ranges from 120 to 140 days (Eichenlaub et al. 1990 cf. Albert 1995) with potential for late spring freezes from cool air descending from adjacent high plains. The daily maximum temperature in July ranges from 24 to 32º C (75 to 90º F) and daily maximum temperature in January ranges from -21 to -4ºC (-5 to 25º F) (Cohen 2000). Average annual precipitation is 32 in. and the average annual snowfall ranges from 70 to 140 in., much the result of lake effect snows off Lake Michigan.

Oak-pine barrens occur on nearly level to slightly undulating ground in well-drained sandy glacial outwash, sandy glacial lake plain, and less often on sandy areas of coarse-

textured moraines (Cohen 2000). Soils are generally coarse-textured, well drained sand or loamy sand of medium to slightly acid pH and low water retaining capacity. The soils typically lack the fine-textured illuvial horizon that is associated with soils in oak openings and are thus doughtier (Cohen 2000). Typically, oak-pine barrens grade into prairie on one front and dry forest on the other (MNFI 1990 cf. Cohen 2000). Curtis (1959 cf. Cohen 2000) described the flora of this community as a mixture of prairie and forest species.

The character of oak-pine barrens can differ dramatically as the result of varying fire intensity and frequency, which is influenced by climatic conditions, soil texture, and topography (Cohen 2000). Infrequent, high intensity fires kill mature oaks and produce barrens covered by scrubby oak sprouts and scattered pines that survive the burns. White (1983, 1986 cf. Chapman et al. 1995) determined that low intensity prescribed fire at one to three year intervals removed woody cover in the sapling and shrub layers but had little effect on large canopy trees (30 cm dbh) in Minnesota oak barrens. Graminoid and forb species increased in importance under this fire regime. Tester's (1989 cf. Chapman et al. 1995) earlier work at the same site indicated that tree density and basal area decreased with greater burning frequency, with most of the reduction occurring in the 5 to 25 cm dbh classes. Species richness increased with fire frequency and his results suggested that two-year burn intervals produced the greatest ground layer diversity. Henderson and Long (1984 cf. Chapman et al. 1995) examined the fire history of two black oak woodlands in northern Indiana and determined that fire frequency and intensity strongly influenced composition and structure. Infrequent, high intensity fires created an open understory, a scrubby sapling layer of black and white oak, and dense cover of herbaceous species. More frequent low intensity fires were associated with higher canopy cover, higher tree density, lower basal area, and lower herb and shrub cover.

Oak Barrens:

Presettlement oak barrens in Michigan occurred across the portion of the Lower Peninsula, classified by Albert (1995) as Section VI., Southern Lower Michigan. This section has a temperate, warm to cool, rainy, snow-forest climate with hot summers and no dry season. Daily maximum temperatures in July range from 29°to 32°C (85°to 90°F) and the daily minimum temperature in January ranges from -9° to -4°C (15º to 25ºF. The number of frost free days is between 120 and 220, and the average number of days per year with snow cover of 2.5 cm or more is between 10 and 60. The mean annual total precipitation is 820 mm (Albert et al. 1986, Barnes 1991, cf. Cohen 2001).

Oak barrens occur on well-drained, nearly level to slightly undulating sandy glacial outwash, and less often on sandy moraines or ice contact features. They typically occur in the driest landscape positions, such as ridge tops, steep slopes, south and west facing slopes, and flat sand plains. The soils are infertile, coarse-textured, well-drained sand or loamy sand with medium to slightly acid pH and low water retaining capacity. Soils contain low organic matter and lack the fine-textured illuvial horizon associated with soil of the oak openings and are thus droughtier (Cohen 2001). Bray (1960) determined that oak barrens soils have low nutrient content compared with forest and prairie soils, noting that black oak and white oak foliage have low calcium content which may not provide

sufficient buffering to prevent leaching of nutrients from the soil. Tilman (1983, 1984 cf. Chapman et al.1995) determined that nitrogen was the major limiting nutrient in the sandy soils found in oak barrens of Cedar Creek Natural Area in east-central Minnesota. Whitford and Whitford (1971 cf. Chapman et al. 1995) indicated that droughty conditions on sandy soils may be a more significant factor in maintaining oak barrens in central Wisconsin than fires. Curtis (1959) considered the oak barrens in the Prairie Province to be the result of intense fires spreading from surrounding prairies into forested areas and creating a mosaic of openings and open canopy forest. This mosaic was maintained by frequent fires, the intensity and frequency of which dictated the species composition. Park-like barrens with widely spaced trees and an open grass understory are maintained by frequent low-intensity fires, which occur often enough to restrict maturation of oak seedlings (Chapman et al. 1995; Faber-Langendoen and Davis 1995, Peterson and Reich 2001 cf. Cohen 2001).

As a fire dependent community type, the suppression and elimination of fire has resulted in significant changes in the structure and composition of oak barrens in the Great Lakes region. In addition, many oak barrens fragments in Michigan are currently completely dominated by black oak as a result of selective harvest of white oak (Minc and Albert 1990 cf. Cohen 2001). When combined with other anthropogenic activities such as livestock grazing and off-road vehicle use, as well as the invasion of exotic species, these communities often support depauperate floristic diversity (MNFI 1995 cf. Cohen 2001).

Range of Natural Viability: Community Distribution and Conditions

Pine Barrens:

Vora (1993) indicates that, based on conversations with several state Department of Natural Resource ecologists, roughly 20,000 km^2 (5 million acres) of pine barrens occurred in Minnesota, Wisconsin, and Michigan. Curtis (1959 cf. Vora 1993) estimated that Wisconsin supported 2.3 million acres (920,000 hectares) of presettlement pine barrens. The pine barrens in Wisconsin are concentrated in Burnett, Washburn, Sawyer, Douglas, and Bayfield counties. Most of the original pine barrens have been altered from historic conditions. The Moquah Barrens area was so altered by loggers, slash and forest fires, unsuccessful farming attempts, and tree planting (32 million trees were planted in the Moquah area alone) that little is left of the original pine barrens and what remains bears little resemblance to the historic landscape (Vora 1993). U.S. General Land Office Survey notes of 1858 reveal great distance between witness trees (the greatest being 308 m) suggesting the presence of openings of perhaps ten or even hundreds of hectares in size (Vora 1993). Overall, the picture that emerges from the 1858 notes is one of a diverse landscape with openings of various sizes, areas with scattered trees, some open forest, and some closed-canopy forests with trees about 60 years old (Vora 1993).

In Michigan, it is estimated that during the 1800's nearly 270,000 acres of pine barrens were present, with 210,000 acres distributed in the Lower Peninsula of Michigan from Kent and Muskegon Counties northeast to Cheboygan and Alpena Counties. Most of the acreage was concentrated in Crawford (55,000 acres), Iosco (33,000 acres), and Oscoda (28,000 acres) Counties. In his study of presettlement conditions in Crawford and

Roscommon Counties, Whitney (1986 cf. Comer 1996) estimated that pine barrens occurred in patches ranging in size from 40 to 7,000 acres. In the Upper Peninsula of Michigan, pine barrens were most concentrated on the Raco Plains of Chippewa County (32,000 acres).

The HMNF historically supported approximately 79,000 acres of barrens/grasslands (HMNF 2003a). Grasslands were included in barrens analysis as the "open" component of the barrens condition on the national forest. The pine barrens ecosystem historically contained a more diverse and different suite of species than is currently found in most of the existing barrens-like habitats. Grass species such as brome grass (*Bromus kalmii*), rough-leaved rice grass (*Oryzopsis asperifolia*), and less commonly rough fescue (*Festuca scabrella*), were significant components of the pine barrens ecosystem. Forbs such as hill's thistle (*Cirsium hillii*), horary puccoon (*Lithospermum canescens*), and bird's foot violet were also commonly found (HMNF 2003a).

Oak-Pine Barrens:

This community type occurs primarily in Michigan. In central Wisconsin, some stands along the sand terraces of major rivers (especially the Black and Chippewa Rivers) may fit the description of this community, but further verification is needed before listing the type (Nature Serve 2003). Prior to European settlement of Michigan, just over 112,000 acres of oak-pine barrens were present in Michigan, covering 0.3% of the state's surface area (Comer et al. 1995 cf. Cohen 2000). Most of the acreage was concentrated in Newaygo County (17% or 19,000 acres), Crawford County (15% or 17,000 areas), and Allegan County (14% or 15,000 acres) (Cohen 2000). Some additional remnants still remain on outwash plains in Menominee and Dickinson Counties.

The Manistee National Forest historically supported approximately 60,000 acres of barrens within the proclamation boundary (HMNF 2003a). Oak-pine barrens ecosystems were historically more diverse and contained a different suite of species than is currently found in existing barrens-like habitats. Grass species such as big bluestem, little bluestem, Indian grass (*Sorghastrum nutans*), and needle grass were common. Forbs such as wild lupine, prickly pear cactus (*Opuntia humifusa*), and dwarf blazing star were also frequently observed.

Oak Barrens:

At the time of settlement, oak barrens probably covered some 11 to 13 million hectares (Nuzzo 1985). Surveyors notes from Michigan in the 1800's indicate that concentrations of oak barrens occurred in the following counties: Oakland (28% or 200,557 acres), Jackson (12% or 84,204 acres), Livingston (11% or 81,176 acres), and Washtenaw (9% or 62,966 acres). These notes indicate that oak barrens covered approximately 719,042 acres or 1.9% of the state, occurring as patches within the lower tier of counties in Michigan (Cohen 2001).

Current Community Condition, Distribution and Abundance

Pine, oak-pine, and oak barrens are considered rare throughout their distribution, the majority of which have either (1) undergone conversion to closed canopy forests due to suppression of fires, (2) been converted to agriculture or plantations, (3) had the principal overstory components removed during logging operations, or (4) succumbed to development. Today these community types occur primarily as small, isolated remnants. Figures 2 and 3 illustrate the landscape that is considered to be compatible with supporting barrens vegetation at any given time in the HMNF relative to those sites that are known to support openings characteristic of historic barrens landscape (Shmidt per comm. 2003). Most historic sites are significantly degraded and support only limited populations of plant and animal indicator species. In Michigan, these community types are all ranked S2, indicating that they are considered imperiled in the state either because of rarity or some factor(s) that make them vulnerable to extirpation from the state.

Pine Barrens:

Eleven pine barrens occurrences have been documented in Michigan, three of which the MNFI (HMNF 2003b) has ranked as high quality ecosystems. The MNFI (HMNF 2003b), indicates that the Manistee National Forest supports one low quality pine barren which covers about 30 acres. The HMNF has assigned this pie barren an F1 rank, which indicates it is considered extremely rare on the Forest. Two high quality pine barrens covering approximately 1,100 acres are known from the Hiawatha National Forest (HMNF 2003b). The one documented pine barren occurrence on the Ottawa National Forest (ONF) is of low quality and covers about 180 acres. Mase and Trull (HMNF 2003b) indicate that the Baraga Plains is the largest pine barrens in the Upper Peninsula, the majority of which occurs in the Baraga State Forest. Jordan (Mase and Trull no date cf. HMNF 2003b) mapped these pine barrens as covering 2,300 acres. Trull (per comm. 2003) indicates that to date the ONF has about 200 acres of pine barrens community type. The ONF ranks this community type as F1. In Michigan, the known occurrences of this community type are found at four sites under private ownership, nine under state ownership, and at four locations within U.S. Forest Service boundaries.

Between 17,000 and 20,000 ha of pine barrens remain in northern Wisconsin, of which perhaps 2,500 ha retain much of its presettlement character (Epstein and Parker per comm. cf. Vora 1993). Spikerman (pers comm. 2003) indicates that approximately 8,000 acres of barrens/savanna landscape occurs on the west side of the Chequamegon National Forest (CNF) in various stages of restoration. He noted that all historic barrens on the CNF were systematically planted to jack and/or red pine during the CCC era of the 1930's following an intense period of logging and slash fires. Eckstein and Moss (1991 cf. Vora 1993) suggest that most remaining barrens are fragments that are too small or isolated to ensure long-term viability of all their characteristic plants and animals. Vora (1993) considers it too late to preserve natural pine-oak barrens in the CNF; however, he indicates that restoration of the major components is possible.

Oak-Pine Barrens:

In Michigan, there are currently sixteen oak-pine barrens recorded in the MNFI database, totaling 3,534 acres (Cohen pers comm. 2003). The average size of the known communities is about 150 acres (Nature Serve 2003). One of the oak-pine barrens is considered high quality, six are good quality, nine are fair to low quality, and one has not been ranked (HMNF 2003b). Overall, this rare community constitutes less than 0.005% of the present vegetation in Michigan, a sixty-fold reduction from the amount of oak-pine barrens originally present (Cohen 2000).

Four occurrences of oak-pine barrens have been documented on the Manistee National Forest, covering about 300 acres. Three of these barrens are of low quality and one is of good quality. This community type has been assigned a F1 rank for the forest. Rabe et al. (1993) indicate that most of the oak-pine barrens within the Manistee National Forest have been converted to closed canopy forest as the result of logging and later fire suppression. In Michigan, the known occurrences of this community type are found at three sites under private ownership, eight under state ownership, and at two locations within U.S. Forest Service boundaries.

Destructive timber exploitation of pines (1880's) and oaks (1920's) combined with post-logging slash fires destroyed or degraded oak-pine barrens across Michigan (MNFI 1995 cf. Cohen 2000). Fire suppression policies instituted in the 1920's resulted in succession of open oak-pine barrens to closed canopy forests dominated by black and white oaks (MNFI 1995 cf. Cohen 2000). Those oak-pine barrens fragments that remain are often lacking the full conifer compliment and have low floristic diversity as a result of fire suppression, livestock grazing, off-road vehicle activity, and the subsequent invasion of exotic species.

Oak Barrens:

In 1985 Nuzzo (1985) reported that 113 sites totaling 2,607 hectares (6,442 acres) of relatively high-quality oak savanna remained in the Midwest, approximately 0.02 percent of the original extent. All but 40 hectares (99 acres) were on sandy, rocky, or similarly droughty substrates. Information provided to Nuzzo (1985) by eight Midwestern states indicated that no intact, high quality deep soil mesic savannas had been located as of 1985. Klopateck et al. (1977 cf. Bacone et al. 1994), estimates that 17-22% of Midwest oak savannas still exist, but most are highly degraded as a result of timber harvesting methods, overgrazing, agricultural use, fragmentation, and especially fire suppression.

The reduction of fire in the landscape resulted in the succession of open oak barrens to closed-canopy forests dominated by black and white oaks, with little advanced regeneration of the oaks and a vanishing graminoid component (Chapman et al. 1995). Many oak barrens fragments are currently completely dominated by black oak as the result of selective harvest of canopy white oak (Minc and Albert 1990 cf. Cohen 2001). In addition, these communities are often depauperate in floristic diversity as the result of

fire suppression and subsequent woody encroachment, livestock grazing, off-road vehicle activity, and the invasion of exotic species (MNFI 1995 cf. Cohen 2001).

The HMNF database (2003b) lists 11 occurrences, constituting just less than 1,100 acres. Two of these are good quality, eight are fair to low quality, and one is poor quality. No oak barrens have been documented by the MNFI on USFS lands. Only the Manistee National Forest is within the historic range of this community (HMNF 2003b). This rare community constitutes less than 0.0005% of the present vegetation in Michigan (Cohen 2001). In Michigan, the known occurrences of this community type are found at two sites under private ownership and four under state ownership. To date no known occurrences are within the HMNF boundaries.

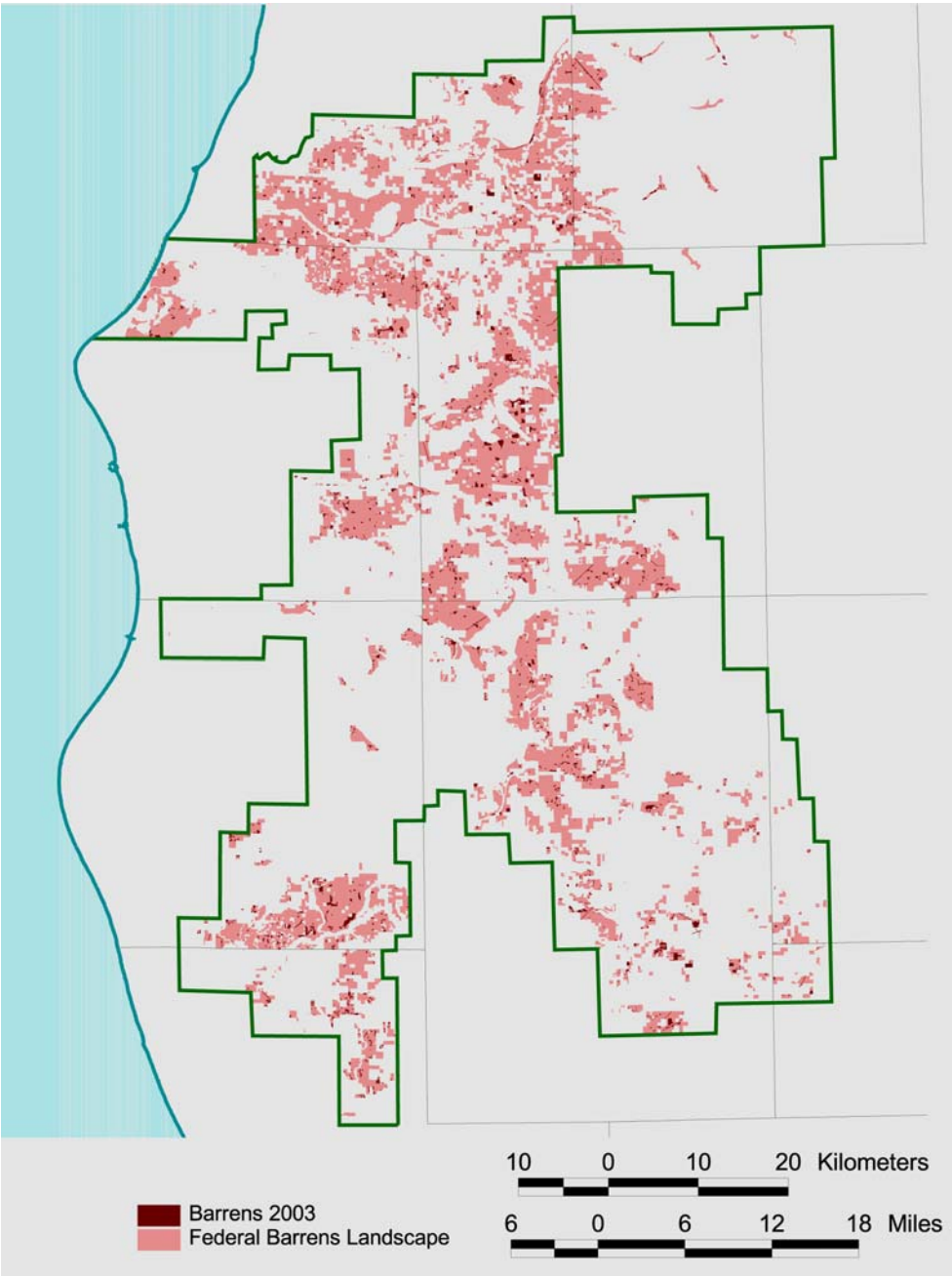

Figure 2. Manistee National Forest barrens landscape and extant barrens.

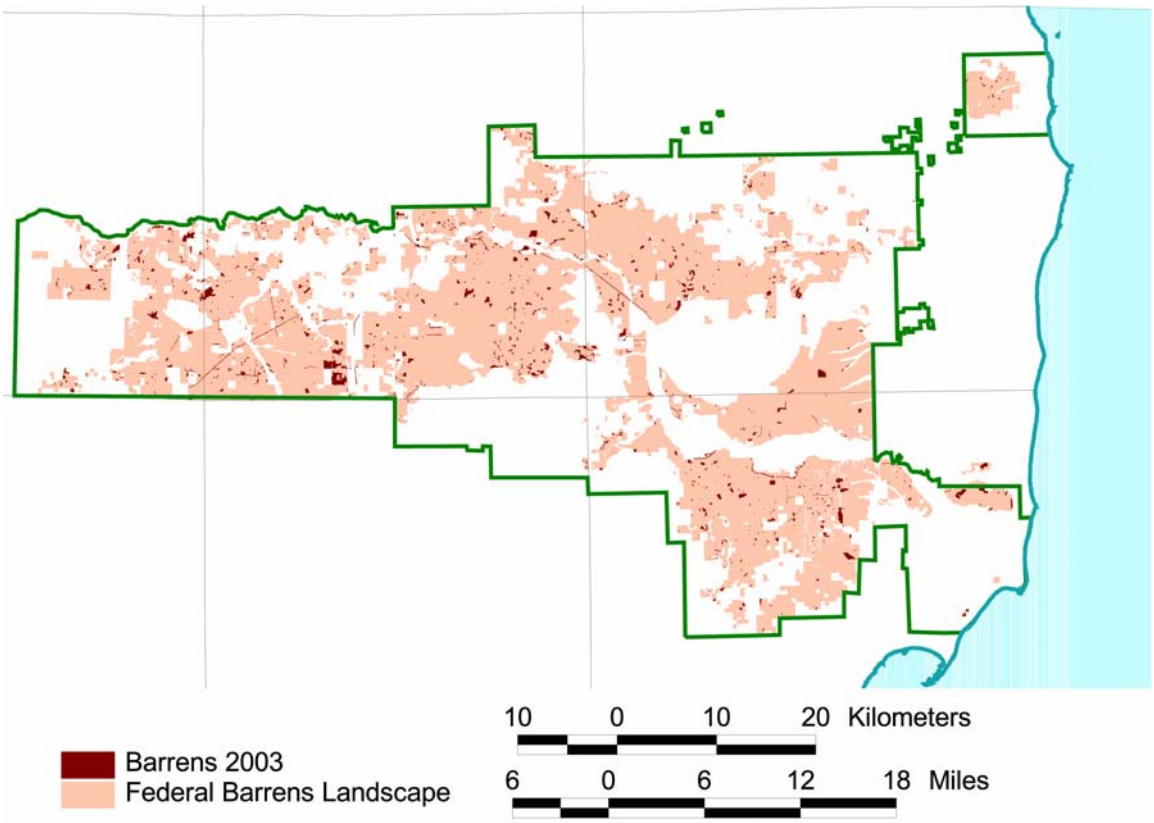

Figure3. Huron National Forest barrens landscape and extant barrens.

Population Viability

A suite of anthropogenic activities has resulted in decreased structural diversity within the barrens landscape, which has negatively affected numerous plant and animal species that are characteristic of barrens environment. Many barrens specialists have been relegated to remnant barrens or structurally similar community types. Those barrens that were not totally destroyed are in a degraded state and often support only vestigial populations of specialists. The small number of remaining high or moderate quality barrens are often separated by considerable distance, thus creating potential genetic isolation. Restoration projects that connect remnants may be an answer to the future viability of many of the species at risk. Until then it is likely that remaining populations will continue to be at risk and some even extirpated. Although several species addressed in this report occur in degraded barrens remnants or similarly structured communities such as road and utility corridors, it is likely that their populations are small. Those species that are at the extreme edge of their range in the HMNF may have always been a small population. Regardless, all the species that are considered rare, due primarily to an extant amount of available barrens habitat, are potentially subject to some environmental, demographic, or genetic stochastic event that may result in their extirpation.

A detailed description of the biology, ecology, and distribution in the HMNF of thirteen plant and animal species that are associated with pine, oak-pine, or oak barrens is

presented below. This is followed by two tables (Tables 1 and 2), which provide a general overview of the thirteen regional forester sensitive species and the known occurrence of each species in the National Forests comprising R9 and the status of each species in those states that comprise the Eastern Region.

Alleghany plum (*Prunus alleghaniensis* var. *davisii*):

The Alleghany plum is a straggling, often thorny, colonial shrub or low tree that grows up to 4 meters in height (Gleason and Cronquist 1991). Material in Michigan is referred to as the disjunct endemic variety *davisii*, which occurs in remnant prairies, old fields, openings in jack pine barrens, and along roadsides in the southern and west-central Lower Peninsula of Michigan. (Voss 1985, Wight 1915 cf. Higman and Penskar 1996a). The largest known stand of Alleghany plum, according to Taylor (1990 cf. Nature Serve 2003), occurs in a "frost pocket" on an east-facing slope above a broad outwash plain in northern Lower Michigan. This species is shade intolerant and in Michigan is restricted to sites with well-drained, acid Grayling sands (Higman and Penskar 1996a). It typically flowers in April with the fruits ripening in August (Higman and Penskar 1996a). Seeds are dispersed by birds and mammals that feed on the fruit. The variety *alleghaniensis* occurs in Pennsylvania, Maryland, West Virginia, Connecticut, and Tennessee in dry, rocky woods and sometimes on shale-barrens habitat (Gleason and Cronquist 1991) and is considered rare in some states.

In Michigan, *Prunus alleghaniensis* var. *davisii* is assigned a Global rank of G4T3Q (i.e. apparently secure globally), a state rank of S3 (i.e. rare or uncommon in state), and a state status of SC (i.e. Special Concern). In the HMNF it occurs primarily in the Newaygo Outwash Plain (NOP) (Subsection VII.3) and Grayling Outwash Plain (GOP) (Sub-Subsection, VII.2.2) regional landscape features. The HMNF (2003c) element occurrence map for this species indicates that it is concentrated in Oscoda and Manistee Counties. As of 2002 a total of 73 plants had been recorded in the Huron National Forest and 35 in the Manistee National Forest (Cleveland communiqué 2003). Data was not available concerning the number of element occurrences that are under state and private ownership.

The development of closed canopy forests has greatly reduced available habitat for this species. Higman and Penskar (1996a) report that although cleared roadsides appear to provide refugia for this species, maintenance activities along them, such as herbiciding and construction, have been known to completely extirpate clonal populations.

Pale agoseris (*Agoseris glauca*):

Pale agoseris is confined to dry, grass-dominated clearings in jack pine barrens and savannas, and roadsides in Michigan. The best populations of this species are known to occur in topographic depressions or frost pockets (Mustard 1979 cf. Higman and Penskar 1996b). Pale agoseris forms a basal rosette of linear, fleshy; bluish-green leaves and produces leafless flower stalks terminating in single, large, yellow flower heads, similar to those of the common dandelion (Higman and Penskar 1996b). A perennial species with a deep taproot and long, silky-haired fruits, pale agoseris utilizes wind for seed dispersal. The relative lack of variability in this species suggests that self-fertilization may be

common. A transcontinental species primarily of the Great Plains, pale agoseris ranges from Alaska eastward to Ontario and south through the Rockies to Arizona (Higman and Penskar 1996b). Within its Michigan distribution, the species is confined to the adjacent portions of Montmorency, Otsego, Crawford, and Oscoda Counties and occurs sparsely and characteristically exists as scattered individual plants.

In Michigan, this species is assigned a Global rank of G5 (i.e. demonstrably secure globally), a state rank of S2 (i.e. imperiled in state), and a state status of T (i.e. threatened). In the HMNF this species occurs only on the Huron National Forest in the GOP regional landscape feature in Oscoda County. As of 2002 a total of 53 plants had been recorded at five sites in the Huron National Forest (Cleveland and Ennis communiqué 2003). Data was not available concerning the number of element occurrences that are under state and private ownership.

Higman and Penskar (1996b) speculate that disturbance events such as wildfires encourage the maintenance of openings within pine barrens and have a positive affect on pale agoseris. Significant pine barrens remnants supporting populations of pale agoseris are now being actively managed and restored in the Huron National Forest (Higman and Penskar 1996b). The principal threat to extant populations of pale agoseris appears to be the development of closed tree canopy and fire suppression.

Hill's thistle (*Cirsium hillii*):

The Great Lakes region is the center of the range of Hill's thistle (Higman and Penskar 1999), with Michigan supporting the largest population (Penskar 1997). Additional states harboring this species include Minnesota, Wisconsin, Iowa, Indiana, Illinois, and Ohio (Penskar 1997); however, it is rather rare in Indiana, Iowa, and Illinois. Hill's thistle is also known to occur in southern Ontario, Canada. This thistle typically inhabits dry, sandy, gravelly soils in prairies, jack pine barrens, oak savanna, open woods, and in Michigan and Wisconsin is also known from alvar communities (Higman and Penskar 1999). This thistle is relatively short in stature and persists for about two to five years (Higman and Penskar 1999). Hill's thistle typically produces a single large flower that blooms from June through August. The basal rosette leaves are oblong in feature and very prostrate. This thistle also reproduces vegetatively by adventitious buds that form along lateral roots (Higman and Penskar 1999).

Penskar (1997) reported a total of 130 occurrences in Michigan at the time of his range wide assessment of the species, noting, however, that this figure was undoubtedly very conservative. This species is assigned a Global rank of G3 (i.e. very rare and local in restricted range) and a state rank of S3 and status of SC in Michigan. In the HMNF this species occurs most often in the Huron National Forest in the GOP regional landscape feature and to a lesser extent in the Manistee National Forest in the NOP regional landscape feature. In the Huron National Forest the occurrences are generally evenly distributed in Crawford, Oscoda, Alcona, and Iosco Counties while in the Manistee National Forest it occurs sporadically in several counties, with one concentration in Newaygo County (HMNF 2003c). As of 2002 a total of 987 plants had been recorded in the Huron National Forest and 72 in the Manistee National Forest (Cleveland

communiqué 2003). Data was not available concerning the number of element occurrences that are under state and private ownership.

Declines in Hill's thistle are largely attributed to fire suppression in natural habitat and the associated increase in litter accumulation, which is thought to be responsible for poor seedling establishment (Higman and Penskar 1999). The lack of fire has also allowed the naturally open barrens to move toward a more closed canopy, thereby reducing the amount of light reaching the ground. Populations of Hill's thistle that occur along utility and transportation corridors may be susceptible to maintenance plans that include the use of herbicide.

Rough fescue (*Festuca scabrella*):

Rough fescue ranges in the west from North Dakota and Colorado to Alaska. In the east it is found in isolated portions of Newfoundland, Quebec, Ontario, and Michigan (Higman and Penskar 1996c). In Michigan, it has been recorded in Crawford, Oscoda, Montmorency, Otsego, Roscommon, and Ogemaw Counties (Higman and Penskar 1996c). Rough fescue inhabits openings in sandy jack pine barrens in Michigan, while in the western portion of its range it occurs in prairies, hillsides, open woods, pine plains, peaty or rocky meadows and barrens, and mountain slopes from foothills to montane areas (Higman and Penskar 1996c). This species forms large robust dense tussocks that reach 3 to 8 dm in height. Associate species often include big bluestem, sweet fern, hair grass, sand cherry, low sweet blueberry, little bluestem, and pale agoseris. This species occurs in fire dependent "prairie like" and barrens community types. Rough fescue is a cool-season grass and commences growth early in the spring, thus fire management of the community harboring this species should avoid late spring burns (Higman and Penskar 1996c). Studies in Alberta indicate that repeated fire does not favor rough fescue, reducing both its cover and inflorescence production (Anderson and Bailey 1980, Bailey and Anderson 1978 cf. Higman and Penskar 1996c).

In Michigan, this species is assigned a Global rank of G5, a state rank of S2S3, and a state status of T. In the HMNF it occurs only in the Huron National Forest within the GOP regional landscape feature and is concentrated in Crawford County. As of 2002 a total of 265 plants had been recorded in the Huron National Forest (Cleveland communiqué 2003). Data was not available concerning the number of element occurrences that are under state and private ownership.

Dusted skipper *(Atrytonopsis hianna*):

Though it has a relatively wide distribution, dusted skipper populations occur in localized and patchy colonies. It ranges from Wyoming, south to New Mexico and central Texas, east to Florida, and north to New Hampshire. With the exception of Maine, this species has been confirmed in all Region 9 States. The dusted skipper occurs in dry, open habitats, oak and pine barrens, grasslands, roadsides, and right-of-ways (Evers 1994, Nielsen 1999, Opler et al. 2000a cf. Stebbins 2001). This skipper has a single generation per year, with adults emerging for a short flight period between late May and the first week of July. Adults have been observed nectaring on plant species such as strawberry

(*Fragaria* sp.), clover (*Trifolium* spp), phlox (*Phlox* sp.), and honey suckle (*Lonicera* sp.), blackberry and raspberry (*Rubus* spp.), cinquefoil (*Potentilla* sp.), yarrow (*Achillea millefoilium*), lupine, puccoon (*Lithospermum* sp), and vervain (*Verbena* sp.) (Evers 1994; Nielsen 1999; Opler et al. 2000a cf. Stebbins 2001). Little bluestem is the principal larval host plant (Nielsen 1999). Larvae eat little bluestem leaves and live in tents constructed from silk near the crown of the host plant. After six molts, the larvae stop feeding, move to the base of the plant, and over-winter in a sealed case of silk and leaves until they pupate in early spring (NPWRC 2003).

This species was assigned a Global rank of G4G5 and a state rank of S2S3 and status of T in Michigan. There have been a total of 58 documented dusted skipper occurrences in Michigan (Ennis communiqué 2003). In the HMNF it occurs primarily in the NOP regional landscape feature. A total of 12 element occurrences exist for this species in the HMNF. The Huron National Forest has two unranked occurrences last observed in 1967 and 1956 and two 2002 records from the Mio Ranger District (HMNF 2003b). The eight occurrences from the Manistee National Forest were observed between 1954 and 1997, with the majority occurring during the 1980's. The skipper has been observed in southern Newaygo, northern Muskegon, northern Mason, and western Oscoda Counties (HMNF 2003b). This RFSS was assigned a F2 rank for the HMNF, which indicates that it is considered very rare within the forest. In Michigan, the known occurrences of this species are found at ten sites under private ownership, eighteen under state, and at seven locations within U.S. Forest Service boundaries (HMNF 2003b).

The elimination or degradation of prairie appears to be the greatest threat to this butterfly species. Habitats spared from development or agriculture is often rendered unsuitable due to plant succession following decades of fire suppression (Evers 1994 cf. Stebbins 2001). Mowing and livestock grazing are considered threats to this species when implemented in May and June because of the reduction of nectar sources (HMNF 2003b). This species is also negatively impacted by overly extensive, excessively hot, or frequent fires which can kill larvae within the burn area (HMNF 2003b).

The extent of suitable habitat required to maintain a viable population of dusted skipper is currently not known. Management practices that call for the reduction of canopy basal area should aid in the maintenance of host and nectar sources. Known adult food sources are encountered both in openings and within the interior of semi-open to closed canopy xeric sites.

Frosted elfin (*Incisalia irus*):

This species occurs in small, local colonies from the upper Midwest States eastward to Maine and New York, south along the Atlantic coast and Appalachians to northern Alabama and Georgia. An isolated colony has also been documented in eastern Texas (NPWRC 2003). With the exception of Minnesota, Iowa, and Missouri, this species has been confirmed in all Region 9 States. Distribution in Michigan is concentrated in the southwestern counties of the Lower Peninsula. The frosted elfin is considered to be threatened throughout its entire range, and has a Global rank of G3 (Opler et al. 2000c cf. Stebbins 2001).

The frosted elfin inhabits native tall-grass prairies, oak-pine barrens, oak savannas, dry-sand prairies, old fields, and roadsides (Evers 1994; Nielsen 1999; Opler et al. 2000c cf. Stebbins 2001). Evers (1994) reports that the species is restricted to areas containing large amounts of wild lupine, which Nielsen (1999) also identifies as the only larval food source in Michigan. It is possible, however, that other plants such wild indigo (*Baptisia tinctoria*), blue false indigo (*Baptisia australis*), and rattlebox (*Crotalaria sagittalis*) also serve as larval food (NPWRC 2003). This species has a single generation per year and over-winters in the pupal stage. Adults hatch in spring and feed on nectar from blueberry flowers (Nielsen 1999 cf. Stebbins 2001). Eggs are laid on lupine, with just one egg placed per plant, and hatch after 3-5 days. Larvae feed on the flowers and developing seedpods and undergo three molts before pupating. Chrysalis hibernates in loose cocoons that are constructed from leaves and silk in litter at the base of the host plant (Evers 1994; NPWRC 2003).

In Michigan, this species is assigned a Global rank of G3, a state rank of S2S3 and a state status of T. There have been a total 66 occurrences of frosted elfin in Michigan (Ennis communiqué 2003). In the HMNF it has been observed only in the Manistee National Forest in the NOP regional landscape features in Newaygo and Montcalm Counties. The Newaygo County site represents the northern extent of this species' range. Though there are currently only four records within the Forest, it is probably more widespread than these occurrences would suggest (HMNF 2003b). Frosted elfin is likely to be found near populations of Karner Blue butterfly (*Lycaeides melissa samuelis*), as they use the same host. This HMNF RFSS species has been assigned a rank of F2. The primary threat to this species is the conversion of oak savannas and open oak-pine forests to other uses, such as farmland and pine plantations (HMNF 2003b). Known occurrences of this species in Michigan are found at eleven sites under private ownership, nineteen under state, and at thirteen locations within U.S. Forest Service boundaries (HMNF 2003b).

Conversion of oak savanna openings and forest edges to closed canopy forest has reduced the available habitat for the frosted elfins host species wild lupine. Restoration and management oak savanna ecosystems for Karner blue butterfly may prove to be beneficial for the frosted elfin.

Ottoe skipper (*Hesperia ottoe*):

This species ranges from southern Manitoba and eastern Montana south along the high plains to Colorado and Texas; east through Nebraska and Kansas to central Illinois and southwest Michigan. It has been recorded in 16 states in this range (HMNF 2003b). The ottoe skipper has been confirmed in the following Region 9 states: Indiana, Illinois, Iowa, Michigan, Minnesota, Missouri, and Wisconsin.

The ottoe skipper inhabits native tall-grass prairies, adjacent roadsides, hills or slopes, and dry sand prairies in Michigan (Haack 1993a; Evers 1994; Nielsen 1999; Opler et al. 2000b cf. Stebbins 2001). Little bluestem and fall witchgrass (*Leptoloma cognatum*) are the primary larval host plants. Adults emerge in July in Michigan and readily nectar on prickly pear cactus, common milkweed (*Asclepias syriaca*), and knapweed (*Centaurea*

spp.*)*. Prickly pear cactus is the preferred nectar source, but this species will also feed on vetch (*Viccia* spp.), alfalfa (*Medicago sativa*), houstonia (*Houstonia* spp.), purple coneflower (*Echinacea* spp.), leadplant (*Amorpha canescens*), compass plant (*Silphium laciniatum*), sunflower (*Helianthus* spp.), aster (*Aster* spp.), and blazing star (*Liatris* spp.) (Cuthrell 2001; NPWRC 2003). Eggs are laid singly near the base of the host plant stem. Larvae hatch within 12 days, eating first their eggshells, and then a variety of local grass leaves (Haack 1993a). Ottoe skippers over-winter as mature larvae in tubal grass nests located slightly below the soil surface (Nielson 1999 cf. Stebbins 2001).

This species is assigned a Global rank of G3G4 and a state rank of S1 (i.e. critically imperiled) and status of T in Michigan. This species is known from 99 element occurrences in Michigan (Ennis communiqué 2003). In the HMNF the ottoe skipper occurs in the NOP regional landscape feature. Its center of concentration in the HMNF is in Newaygo, Mecosta, and Montcalm Counties. There are also six historic element occurrences in the HMNF. Three of these occurrences were last observed between 1980 and 1983, however, no additional occurrences were observed during recent searches (HMNF 2003b). Most sites have been assigned an F rank, indicating that habitat is still present but recent surveys failed to find the element (HMNF 2003b). In Michigan, the known occurrences of this species are found at eight sites under private ownership, fifteen under state, and at four locations within U.S. Forest Service boundaries (HMNF 2003b).

Habitat loss and degradation are the immediate threats to this species (Stebbins 2001). Off-road vehicles, agricultural and silvicultural practices, and development continue to destroy habitat for Ottoe skipper (Cuthrell 2001). Fire suppression has encouraged the closing of formerly open-canopied oak and oak-pine barrens and reduced the size and quality of adjoining sand prairies.

Persius duskywing (*Erynnis persius*):

The persius duskywing is represented in the west by the nominate subspecies *borealis* which ranges from Alaska and northwestern Canada southward to the mountains of Colorado, Arizona, and New Mexico. The nominate subspecies *persius* exists in uncommon, disjunctive, and sparse populations in the east, occurring from eastern Minnesota to Maine, extending southward along the Appalachian Mountains (NPWRC 2003b, HMNF 2003b). The persius duskywing is found among open, sandy habitats such as oak and pine barrens, grasslands, brushy fields, and along trails and utility corridors that traverse barrens (Evers 1994; Nielsen 1999 cf. Stebbins 2001). This species appears to be restricted to areas with large populations of the host plant, lupine, but has been observed utilizing wild indigo as well. This skipper has a single generation and adult flight period in May (Nielsen 1999 cf. Stebbins 2001). Eggs are deposited singly on the underside of host plant leaves. Larvae eat leaves and live in rolled or tied leaf shelters. They over-winter in a mature larval stage and pupate the following spring (NPWRC 2003).

In Michigan, this species is assigned a Global rank of G5T2T3, a state rank of S3, and a state status of T. There have been 109 documented element occurrences (Ennis

communiqué 2003) from 30 locations in 15 counties in the southern half of the Lower Peninsula Michigan (HMNF 2003b). In the HMNF it occurs primarily in the NOP regional landscape feature. It has been observed in Montcalm and Oceana Counties in the HMNF (HMNF 2003b). There are five known localities harboring this species in the HMNF and three nearby (HMNF 2003b). Persius duskywing is probably substantially more widespread; however, confirming the presence of persius duskywing can be problematic due to there rapid flight and difficulty of identification (HMNF 2003b). It is ranked as an F2 species in the HMNF. Data was not available on the ownership of the land harboring the known element occurrences. The HMNF is at the northern range of this species.

Habitat loss and degradation, especially of large populations of lupine growing in open areas, are thought to pose the greatest threat to this species. The conversion of oak savannas and open oak-pine forests to farmland and pine plantations is considered a principal threat to the species (HMNF 2003b). Restoration that promotes the maintenance of lupine, such as that proposed for the Karner blue butterfly, would likely benefit the persius duskywing.

Phlox moth (*Schinia Indiana*):

The phlox moth has been confirmed in Illinois, Indiana, Michigan, Minnesota, Wisconsin, and Arkansas, and unsubstantiated records exist for Nebraska, North Carolina, and Texas (MNFI 1990). This species primarily occurs in prairies and pine-oak barrens on sandy soil (MNFI 1990), but has also been observed in utility right-of-ways, dirt roads, trails, and the periphery of home sites (Haack 1993b). Prairie phlox (*Phlox pilosa*) is the principal larval host plant. Hardwick's (1958 cf. MNFI 1990) laboratory observations from individuals raised on *Phlox divaricata* (woodland phlox) is the only known source of life history and ecological information on this species. Adult phlox moths emerge in June and are camouflaged well on the host plant, where they spend most of their time. Having a single generation per year, the eggs of this moth are laid on the inner surfaces of the sepals. Newly hatched larvae feed on the bud, flowers, and seed capsules, while older larvae feed from the outside of the seed capsule until it is empty, and then cut the stem to drop the boll (Evers 1994 cf. Stebbins 2001; Haack 1993b). The larvae seal their entrance holes with silk, are released from the capsule when it dehisces, and over-winter underground in the pupal stage (Haack 1993b).

Phlox moth is assigned a Global rank of GU (i.e. possibly in peril rangewide) and a state rank of S1S2 and status of E (i.e. endangered) in Michigan. There have been 12 element occurrences recorded since the species was first documented in 1985 (Ennis communiqué 2003). Phlox moth is known from two sites in Newaygo and Montcalm Counties in the Manistee National Forest (HMNF 2003b). These sites occur within the NOP regional landscape feature. This species has been assigned a F1 rank in the HMNF (HMNF 2003b). Phlox moth could occur at additional sites supporting its host plant; however, to date no systematic surveys for the species have been conducted (HMNF 2003b).

The existing element occurrences in Michigan are along roadsides. A reduction in the amount of available prairie and oak barrens habitat that support the host species may have

affected the historical occurrence of this species. Phlox moth is susceptible to mortality caused by mowing or herbiciding of the host plant along roads (HMNF 2003b). Additional threats include off-road vehicle damage and development.

Regal fritillary (*Speyeria idalia*):

The regal fritillary ranges from Montana and North Dakota south to Colorado, Nebraska, and Oklahoma. It is relatively rare in its former range east of the Appalachians (NPWRC 2003). With the exception of Vermont, this species has been confirmed in all Region 9 States. This species inhabits a variety of open habitats, including dry prairies, riparian areas, meadows, pastures, and marshes (Evers 1994; Opler et al. 2000d cf. Stebbins 2001); however, in the Midwest it is most abundant in tall-grass prairies (Bliss 1987).

Adult emerge in June and July and nectar on numerous species, including milkweeds, thistles, blazing star, red clover, and mountain mint (Bliss 1987; NPWRC 2003). Eggs hatch within three to four weeks. The newly emerged larvae seek shelter beneath leaves near the ground surface, and then immediately go into diapause without feeding. As temperatures rise the following spring, larvae nocturnally feed on leaves of nearby violets, but remain inactive and hidden during the day. Although the larvae feed on a wide variety of violets (*Viola* spp.) (Evers 1994; Opler et al. 2000d cf. Stebbins 2001), adults do not necessarily oviposit on the violets. After five molts, larvae form a chrysalis from which they emerge in approximately 17 days (Bliss 1987; Evers 1994 cf. Stebbins 2001).

Regal fritillary is assigned a Global rank of G3 and a state rank of SH (i.e. of historical occurrence but suspected to be extinct) and status of E in Michigan. The regal fritillary is historically known from 39 occurrences (Ennis communiqué 2003) from 26 locations in 18 counties (HMNF 2003b). Within the Huron-Manistee National Forest, it has been recorded at five locations, however, it was last observed in the forest in 1963. Occurrences occur primarily within the NOP regional landscape feature. There are three documented occurrences in Newaygo County (MNFI 1999; Nielsen 1999 cf. Stebbins 2001; HMNF 2003). Regal fritillary was assigned a F1 rank in the HMNF (HMNF 2003b). In Michigan, the known occurrences of this species are found at nine sites under private ownership, thirteen under state ownership, and at three locations within U.S. Forest Service boundaries (HMNF 2003b). The northern most records for the HMNF are in Iosco County (HMNF 2003b).

Although apparently able to maintain itself in very small populations within remnant habitats, the species has been rapidly vanishing in much of its range. It is listed as species of concern by the U.S. Fish and Wildlife Service (NPWRC 2003). The underlying cause of this species' dramatic decline in the eastern half of the U.S. is poorly understood. The most commonly cited cause is the widespread fragmentation of its native tall-grass prairie habitat. Some feel that the species is sensitive to the overuse of fire in prairie restoration (HMNF 2003b). The species has always been scarce; occurring in small, much localized populations that only persisted at any given site for a few years (HMNF 2003b).

Southern grizzled skipper (*Pyrgus wyandot*):

The southern grizzled skipper has a fragmented Holarctic range. In North America, this species occurs from Alaska south and east to central Ontario and northern Michigan. Isolated populations exist in Labrador and arctic Quebec, the central Appalachian, and the Rocky Mountains from Alberta south to New Mexico (Haack 1993c; NPWRC 2003). Michigan populations of grizzled skipper are clustered in the northern Lower Peninsula (Nielsen 1999 cf. Stebbins 2001). The taxonomic status of this species in Michigan is under review. Should this work reveal the Michigan specimens to be a separate species, its distribution would be limited to Michigan (HMNF 2003b).

Grizzled skippers typically occur in large openings in sandy pine and oak barrens, but they have also been observed along trails and roadsides, in scrub oak openings, abandoned agricultural fields, and disturbed areas (Allen & Van Dam 1993; Haack 1993c; Nielsen 1999 cf. Stebbins 2001). Moisture is an important habitat component, as males are known to congregate at small water sources such as streamlets (HNMF 2003b). In Michigan, wild strawberry is the only known larvae host plant, however, cinquefoil (*Potentilla canadensis*) is utilized elsewhere (Allen & Van Dam 1993; Nielsen 1999 cf. Stebbins 2001). Having a single generation each year, grizzled skipper adults emerge in early May and nectar on wild strawberry (*Fragaria virginiana*), bird's foot violet (*Lotus corniculatus*), Canada cinquefoil, spring beauty (*Claytonia virginica*), phlox (*Phlox* sp.), blueberry (*Vaccinium* sp.), bearberry (*Arctostaphylos uva-ursi*), and dandelion (*Taraxacum* sp.) (Allen & Van Dam 1993; Nielsen 1999 cf. Stebbins 2001). Females oviposit in the afternoon, depositing eggs singly on the underside of host plant leaves. The larvae hatch after 8-10 days, and shortly thereafter construct a nest from silk and leaves that they use for shelter while feeding. As the larvae grow, they move to different leaves and build new nests (Allen & Van Dam 1993 cf. Stebbins 2001). Larvae are very slow-growing compared to other similar species; typically 100 days pass between the hatching of the egg and the pupating of the sixth instar, which takes place in late summer in a sealed leaf shelter close to the ground (Allen & Van Dam 1993 cf. Stebbins 2001).

In Michigan, this species is assigned a Global rank of G2, as state rank of S1S2, and a state status of T. Five element occurrences of grizzled skipper have been recorded on the HMNF, one each in Oscoda and Wexford Counties from the 1950's, and three in western Montcalm County from the mid-1980's (HMNF 2003b). In Michigan, the known occurrences of this species are found at six sites under private ownership, eleven under state ownership, and at four locations within U.S. Forest Service boundaries (HMNF 2003b).

Evidence suggests that the decline of southern grizzled skipper populations in portions of its range can be attributed to the use of Dimilin and Bt in gypsy moth control efforts (Allen & Van Dam 1993 cf. HMNF 2001). Populations have been extirpated in Maryland, West Virginia, New Jersey, and Pennsylvania (Haack 1993c).

Sprague's pygarctia (*Pygarctia spraguei*):

Sprague's pygarctia is known from some states in a range that extends from Michigan south to Louisiana and west to New Mexico (Forbes 1960; Holland 1968 cf. Legge 1995). The species occurs in degraded oak barrens, sand prairies, and weedy old fields (Legge et al. 1995). The larval host plant is spurge (*Euphorbia* spp.) (Barnes and McDunnough 1912 cf. Legge 1995), and in Michigan painted-leaf spurge (*E. heterophylla*) or flowering spurge (*E. corrollata*) are preferred (Stebbins 2001). There is limited information on the life history of this species. It is believed to have a single generation per year, with adult emergence in May and June, and it is thought that the eggs are laid on or near the host plant (Legge 1995). Captive-reared larvae have five instars, pupating on or slightly beneath the ground in a cocoon comprised of mixed hairs and earth. It is presumed that under natural conditions the species over winters in the pupae stage (Legge 1995).

This species is assigned a Global rank of G3G4 and has a state rank of S2S3 and state status of SC in Michigan. Five element occurrences of this species have been documented in Michigan (Ennis communiqué 2003). One occurrence is within the HMNF in Newaygo County (HMNF 2003b). Sprague's pygarctia is probably substantially more widespread in oak savanna, oak-pine forest, and sand prairie than the single record suggests (HMNF 2003b). It has been assigned a rank of F1 in the HMNF (HMNF 2003b). In Michigan, the known occurrences of this species are found at three sites under private ownership, four under state, and at one location within U.S. Forest Service boundaries (HMNF 2003b).

Habitat loss is likely the principal factor restricting Sprague's pygarctia populations. Field research projects targeting the ecology and life history of this moth species would provide valuable information needed to adequately assess potential threats and management options.

Great Plains spittlebug (*Lepyronia gibbosa*):

The Great Plains spittlebug has been collected across the Great Plains from Texas to Manitoba and east to Massachusetts. To date, only Michigan is currently tracking this species (Nature Serve 2003). This spittlebug typically occurs in narrow, mesic zones around frost pockets in sandy glacial outwash in Michigan (Evers 1994; Whittaker 1994 cf. Stebbins 2001). It is considered a prairie endemic species that occupies the rare sand prairies and oak savannas of Michigan (Dunn et al. 2002).

Seasonal distribution of nymphs occurred from 17 May until 10 June, and adults occurred from 20 June through 7 September in Michigan (Dunn et al. 2002). Host plant records indicate that the nymphs were highly polyphagous with collections from ten different plant families ranging from grasses and forbs to woody plants. In contrast, adults were found to be monophagous with collection records only on big and little bluestem (Dunn et al. 2002).

In Michigan, this species is assigned a Global rank of G3G4, a state rank of S1S2, and a state status of T. Gill (HMNF data base 2001) observed the species at several frost pockets in the HMNF ranging from one to 21 acres in size. Dunn et al. (2002) has 34

documented occurrences of this species within the Huron-Manistee National Forest in Lake, Mason, Muskegon, and Newaygo Counties. In the HMNF many sites occur within the NOP regional landscape feature. Of the additional 23 sites in which Dunn et al. observed this species, ten are under private ownership, five under state ownership, and eight are under the ownership of preservation organizations (Dunn et al 2002).

Great Plains spittlebug is more common than previously thought; however, all sites are in very poor ecological condition due to the invasion of Pennsylvania sedge and exotic plants, which are reducing the cover of little and big bluestem (Dunn et al. 2002). Most sites for this species are also being disturbed by off-road vehicles and camping (Dunn per comm. 2003).

Table 1: Regional Forester Sensitive Species Assessment Table

Species	Subsection [1]	Community	Canopy	Other site factors	Host plant(s)	Management Sensitivity

Prunus alleghaniensis v. davisii (Alleghany plum)	VII.3 VII.2	JP barrens;	Scattered JP over grasses and forbs	Droughty soils; roadsides	NA	Closed canopy development; roadside maintenance
Agoseris glauca (Pale agoseris)	VII.2.2	JP barrens; frost pockets	Scattered JP over grasses and forbs	Droughty soils;	NA	Closed canopy development
Cirsium hillii (Hill's thistle)	VII.2.2 VII.1.1 VII.3 VII.4	JP barrens;	Scattered JP over grasses and forbs	Droughty soils; edge of corridors	NA	Closed canopy development; maintenance of rights-of-way
Festuca scabrella (Rough fescue)	VII.2.2	JP barrens; sand openings	Scattered JP over grasses and forbs	Droughty soils,	NA	Closed canopy development.
Atrytonopsis hianna (Dusted skipper)	VII.3	OP barrens;	Scattered OP over grasses and forbs	Droughty soils; forest edges	Little bluestem (larvae); blackberry, cinquefoil, lupine (adult)	Land conversion; livestock grazing
Incisalia irus (Frosted elfin)	VII.3 VI.4	O barrens; O savannas	Scattered O over grasses and forbs	Droughty soils; openings	Lupine -(larvae), blueberry - (adult)	Closed canopy development; land conversion
Hesperia ottoe (Ottoe skipper)	VII.3	Prairies;	Grasses and forbs	Droughty soils; utility and trans. corridors	Witchgrass. Little bluestem (larvae); alfalfa, aster, dotted monarda, prickly pear cactus, etc.	Closed canopy development
Erynnis persius (Persius duskywing)	VII.3 VII.4	OP barrens	Scattered OP over grasses and forbs	Droughty soils; openings	Lupine (larvae); Blueberry, lupine, downy phlox, birdfoot violet	Closed canopy development
Schinia indiana (Phlox moth)	VII.3	Prairies; OP barrens; roadsides	Scattered JP over grasses and forbs	Droughty soils;	Prairie phlox (larvae);	Closed canopy development
Speyeria idalia (Regal fritillary)	VI.4	Prairie	Scattered JP over grasses and forbs	Droughty soils	Violets (larvae); Milkweed, thistle, blazing star etc. (adult);	Land conversion;
Pyrgus wyandot (Southern grizzled skipper)	VII.3	OP barrens;	Scattered JP over grasses and forbs	Droughty soils; roadsides	Wild strawberry (larvae); bird's foot violet Canada cinquefoil, phlox, blueberry etc. (adults)	Closed canopy development
Pygarctica spraguei (Sprague's pygarctia)	VII.3	OP barrens; sand prairies	Scattered JP over grasses and forbs	Droughty soils;	Spurge (larvae)	Closed canopy development
Lepyronia gibbosa (Great Plains spittlebug)	VII.3 VI.4	O barrens;	Scattered JP over grasses and forbs	Droughty soils; sand prairies; edges	Little bluestem, big bluestem, switch grass, meadow fescue, , etc. (nymphs)	Closed canopy development

[1] VI.4 - Ionia; VII.1.1 - Standish; VII.2 - Highplains; VII.2.2 - Grayling Outwash Plain; VII.3 - Newaygo Outwash Plains; VII.4 - Manistee

Table 2: Known occurrence of 13 species in R9 Forests and status of species in states comprising the Eastern Region.

SPECIES

	Prunus alleghaniens is var.	*Agoseris glauca*	*Cirsium hillii*	*Festuca scabrella*	*Atrytonopsis hianna*	*Incisalia irus*	*Hesperia ottoe*	*Erynnis persius persius*	*Schinia indiana*	*Speyeria idalia*	*Pyrgus wyandot*	*Pygarctica spraguei*	*Lepyronia gibbosa*
NATIONAL FORESTS													
AL	?	?	?	?	?	?	?	?	?	?	?	?	?
CNNF													
CP		*											
GMFL													
HI					P	?	?	?	?	?	?	?	?
HO											X		
HM	X	X	X	X	X	X	X	X	X	X	X	X	X
MT													
ME			X										
MO					?	?	?	?	?	?	X	?	?
OT													
SH													
SU													
WN					P								
WM													
STATES													
IL			T			SH	T	SR		S1/T			
IN			S1/E			S2		S1		S1			
MI	G4T3Q S3/SC	G5 S2/T	G3 S3/SC	G5 S2S3/T	G4G5 S2S3/T	G3 S2S3/T	G3G4 S1S2/T	G5T2T3 S3/T	GU S1S2/E	G3 SH/E	G2 S1S2/T	G3G4 S2S3/SC	G3G4 S1S2/T
MN							T	S1/E	SC	SU/SC			
IL			T			SH	T	SR		S1/T			
IN			S1/E			S2		S1		S1			
MO							S2S3			S3			
NH						E		E					
NY					S3/U	S1S3/T		SH/E		SH/E	SH/E		
OH						S1				SH			
PE					S3	S2		S1S2		S1	S1		
VT										SX/SC			
WV					S1					S1	S1		
W1			S3/T		S2/SC	S1/E	S2/SC	S2/SC	S2/E	S1/E			

AL=Alleghany; CNNF=Chequamegon Nicolet; CP=Chippewa; GMFL=Green Mountain/FingerLake; HI=Hiawatha; HO=Hoosier; HM=Huron Manistee; MT=Mark Twain; ME=Medewin; MO=Monogahela; OT=Ottawa; SH=Shawnee; SU=Superior; WN=Wayne; WM=White Mountain

* = In proclamation boundary but not designated as Regional Forester Sensitive Species; P=Potentially occurring in Forest;
? = Information lacking; Blank box indicates that species is not known to occur in the in the Forest.

Global ranking: G1=critically imperiled globally; G2=imperiled globally; G3=either very rare or local; G4=apparently secure globally; G5=demonstrably secure globally; GU=possibly in peril; State ranking: S1=Extremely rare; S2=rare; S3=uncommon; S4=apparently secure; SH=State historical occurrence; SU=possibly in peril in state but status uncertain; SR=reported from state but not documented State status: E=Endangered; T=Threatened: SC=Special Concern. A blank box means the species is not listed or does not occur in the state.

Potential Threats

The principal potential threats to pine, oak-pine, and oak barrens community types are fire suppression and land use conversion. These threats significantly affect landscape ecological and biological diversity. As fire dependent ecosystems, the suppression of fire has resulted in the gradual development of closed forest canopies and a reduction in available habitat for numerous plants, vertebrates, and invertebrates. Fire is the predominant disturbance in the jack pine community, and prior to the arrival of European settlers, it influenced the dynamics and structure of this ecosystem in Wisconsin, northern Minnesota (Heinselman 1973 cf. Pregitzer and Saunders 1999), and Michigan (Simard and Blank 1982 cf. Pregitzer and Saunders 1999). Writing about New Jersey pine barrens, Smith (1765 cf. Little 1979) indicated that before European settlements, Native Americans regularly burned the woods to facilitate hunting. Fire suppression and timber exploitation of pines in the oak-pine barrens resulted in the development of forests dominated by black and white oaks. Oak barrens probably originated primarily as the result of intense fires occurring in the forest dominated landscape (Curtis 1959, Rogers and Anderson 1979 cf. Anderson and Bowles 1999). Frequent fires on flat to gently rolling terrain with droughty soils helped to maintain a scattered canopy of fire tolerant oak, with a grass, forb, and shrub understory. Fire significantly influenced the development and appearance of both open and scrub savannas, but did not eliminate the oaks (Curtis 1959, Grimm 1984, Irving 1981 cf. Nuzzo 1985).

Remaining remnant barrens continue to be threatened by tree encroachment, although this process is typically slower on sandy droughty soils versus rich soils. The development of dense forest canopy results in increased fuel loads. Should fire return to the system, the intensity is often great enough to kill the canopy trees, promote dense sprouting of trees and reduction in open areas. Under natural conditions, frequent low intensity fires rarely killed the canopy trees and maintained an open understory. Tester's (1989) study of the effects of fire frequency on oak savanna at Cedar Creek in east-central Minnesota indicated that frequent burning leads to an increase in true prairie species and a decrease in forest species. Kucera and Koelling (1964 cf. Tester 1989) also reported that burning every other year in a Missouri prairie controlled the invasion of woody species, yet resulted in higher overall species richness.

The presence of Pennsylvania sedge can pose a specific problem for the management of barrens. Cope (1992 cf. Comer, 1997) found that, in the absence of fire, Pennsylvania sedge tends to out-competes other herbaceous plants through its ability to aggressively form clones. But, burning sites following the removal of canopy trees has had mixed results for the control of the sedge. Albert (pers. comm. in Comer, 1997) noted that sedge density decreased following prescribed burns at the Shakey Lakes barrens in Menominee County, Michigan. Cleveland (pers. comm. 2004), however, indicates that at some sites this sedge continues to be problem in spite of a succession of prescribed burns.

Many species, in addition to the thirteen described above, have been adversely affected by the elimination and degradation of barrens. Although many rare species continue to persist in remnant or degraded communities, they are often widely dispersed. In his studies of prairie insects, Panzer (1988) indicated that despite their relatively small size, pronounced isolation, and degraded condition, Midwestern prairie remnants continue to harbor prairie-restricted insects. Even sites as small as 2 ha (5 acres) routinely support a

few restricted species (Panzer and DeMauro 1983b cf. Panzer 1988). Nielsen (per comm. 2003) suggested that a minimum 10-acre remnant is required to support a population of Ottoe skipper. Cuthrell (per comm. 2003) estimates that many of the insects dealt with in this assessment require between 50-100 acres of habitat to subsist. These small populations are, however, subject to the debilitating effects of demographic instability, genetic deterioration, and natural catastrophes such as storms, floods, and epidemics (Wilcove 1987 cf. Panzer 1988). Several attributes, including fluctuating population densities, poor dispersal abilities, and patchy distributions, make remnant-restricted insects particularly susceptible to these extinction-causing phenomena (Panzer 1988). Habitat-restricted butterflies are often quite sedentary (Ehrlich 1961, Schweitzer 1985a cf. Panzer 1988) and, in some cases, incapable of negotiating barriers as seemingly inconsequential as roads, open fields (Cappuccino and Kareiva 1985 cf. Panzer 1988), and chain link fences (Wourms 1984 cf. Panzer 1988). The inability or disinclination of many remnant-restricted insects to traverse the considerable distances that separate remnants predisposes these organisms to extinction (Panzer 1988). The influx of opportunistic and ecotonal organisms from human-dominated habitats also poses potential threat of extinction to remnant-restricted insects through predation and competition (Panzer 1988).

Extensive areas of pine, oak-pine, and oak barrens have undergone conversion to agriculture, tree plantations, and urban, suburban, and industrial development. Early settlers were attracted to barrens because they were easily farmed. However, the poor droughty soils forced abandonment of the land when crops failed. Today these sites often support high densities of exotic invasive weeds that compete with residual native species. Persistent herbaceous species such as leafy spurge (*Euphorbia esula*), spotted knapweed (*Centaurea maculosa*), Canada thistle (*Cirsium arvense*), white and yellow sweet clover (*Melilotus alba* and *M. officinalis*, respectively), and smooth brome (*Bromus inermis*) are difficult to eradicate and pose a serious problem for barrens restoration. Additional specific threats to oak barrens include defoliation from gypsy moth (*Lymantria dispar*), oak wilt, drought, and root rot.

The historic barrens continue to come under the pressure of development, the extent to which is not known. Sand mining has taken its toll on barrens communities, primarily within the dune systems adjacent the Great Lakes. The conversion of historic barrens to pine plantations occurred in earnest following the logging era. Red and jack pine plantations dominate large expanses of land that supported pine barrens throughout the Great Lakes region. These relatively dense plantations have eliminated the majority of barrens herbaceous species.

Summary of Land Ownership and Exiting Habitat Protection

Today, the majority of pine, oak-pine, and oak barrens has either been extirpated or is in a degraded condition. In the State of Michigan, the MNFI indicates that a total of 36 sites that support characteristic pine, oak-pine, or oak barrens have been identified (HMNF 2003b). Of these, nine are under private ownership, twenty-one are under state ownership, and six occur on federally owned land. The total acreage under these individual ownerships was not available during preparation of this report.

In Michigan, management plans have been developed for 1400 acres of pine barrens in the AuSable State Forest (i.e. Frost Pocket Pine Barrens Management Plan) and 5,000 acres on Camp Grayling (i.e. North Camp Grayling Pine Barrens Management Plan) (Kost communiqué 2003). The largest significant and manageable tract of oak savanna (i.e. oak barrens, oak-pine barrens, and oak openings) in Michigan occurs in the Allegan State Game Area. Roughly 22,000 acres has been identified for oak savanna management as part of the Karner blue butterfly recovery plan (Lerg per comm. 2003). Approximately 6,000 acres in the Flat River State Game Area have been identified for prospective oak savanna management (Lerg per comm. 2003). Approximately 4,000 acres of privately owned land in Kent County that is bisected by a MDNR rails to trails path has been identified as a potential oak savanna management area (Lerg per comm.. 2003). The Shakey Lakes Oak Savanna, a designated Natural Area in the Escanaba State Forest, contains large areas of oak-pine barrens and several State of Michigan rare plant species (EPA 1995).

The HMNF reports that there is approximately 20,339 acres of land in what has been called the "barrens-like phase" in the Forest (HMNF Forest Plan Revision Draft 2003d). These lands are primarily located on the outwash sands and ice contact sandy hills. The HMNF currently has one established (i.e. Newaygo Prairies-180 acres) and three proposed Research Natural Areas that support dry sand prairies and/or oak-pine barrens community types (USDA 2002).

Summary of Existing Management Activities

Much of the literature on managing barrens has focused on the process by which to restore the barrens community structure through canopy reduction and prescribed burns at various intensities and time intervals (Rabe et al. 1993, Kline 1994, Anderson and Schwegman 1991, Tester 1989, Faber- Langendoen and Davis 1995, McCarty 1993, Packard 1988, White 1983). Most historic pine, oak-pine, and oak barrens, with the exception of some frost pocket pine barrens; currently support high densities of canopy trees, with relatively high understory fuel loads. Under these conditions using fire to reduce the canopy could negatively impact the entire canopy structure. It appears more plausible to utilize timber harvesting to reduce the basal area followed by a well orchestrated low intensity burn plan. The frequency of burning will vary with the individual site and a full understanding of the ecological conditions at each site is imperative, particularly in those that are known to harbor rare species.

McCarty (1993) indicates that restoring degraded savannas and woodlands in Missouri requires a reopening of the midstory to allow light to reach the ground and an initiation of fire. Following the initial removal of midstory trees, fires are utilized to discourage

woody plants in favor of grasses and forbs. Managers' prefer to burn frequently in the early stages, primarily to control oak sprouts and prevent litter buildup while the herbaceous plants recover (McCarty 1993). It is important that the fires be of low intensity to avoid excessive damage to target plant species. Studies have indicated that fire intervals of 1-3 years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs (White 1983, Tester 1989 cf. Cohen 2001).

In the Allegan State Game area, the Michigan Department of Natural Resources (MNDR) is using timber harvesting, fires, chemical treatment, and mowing to connect openings and create habitat for the Karner Blue butterfly (EPA 1995, Lerg per comm.. 2003). In the Shakey Lakes Oak Savanna, the MDNR has implemented salvage cutting and burning on a limited basis, however, this project has been controversial (EPA 1995). Smith (per comm. 2003) indicates that roughly 500 acres in southwestern and central Montmorency County have been planned for pine barrens restoration. One approximate 70-acre site that was burned resulted in significant positive response in the number of Hill's thistle present at the site (Smith per comm. 2003). The Nature Conservancy is currently restoring/managing approximately 650 acres of oak-pine barrens and 400 acres of oak savanna type in southern Michigan (McGowan-Stinski per comm. 2003).

Since 1986, the CNF has implemented large-scale restoration activities to reestablish missing ecosystem components in the Riley Lake and Moquah Barrens Wildlife Management Areas (Vora 1993 cf. CNF 2003). Permanent and temporary openings have increased by 65 acres at Riley Lake and by 1700 acres adjacent to the Moquah Barrens, improving the structural characteristics of these ecosystems. Additionally, prescribed fire has been used more frequently as a disturbance agent in place of mechanical treatments in an attempt to restore important natural ecological processes (CNF 2003).

The HMNF Plan Revisions (HMNF 2003d) provide guidelines for RFSS that call for restoring and maintaining approximately 58,600 acres in grassland, prairie, savannah, and oak-pine barrens in the sandy hills and plains land type associations. The size of the openings may be up to 500 acres and are to be maintained for the dusted skipper, which is used as a surrogate species (HMNF 2003d). There is much potential for restoration of barrens in the HMNF as illustrated (see Figures 2 and 3) by the extent of the barrens landscape in the Forest.

Karner blue butterfly habitat management in the HMNF, which includes timber harvesting and prescribed burning to increase the larvae host plant wild lupine, may potentially benefit the persius duskywinged, whose larvae also feeds on this plant, as well as numerous barrens indicator plant species. The management will include maintaining savanna-like conditions with 25-50 percent crown closure. The Karner blue butterfly recovery action units on the Manistee National Forest have approximately 2,026 acres (820 ha) of occupied habitat (Joe Kelly per comm. USFWS 2003). To date 500 acres (202 ha) of this barrens habitat has undergone restoration treatments, with another 675 acres (276 ha) scheduled for treatment under the current Forest Plan (USFWS 2003). Prescribed burning is an important tool used in the HMNF to reduce fuel in forest, create additional habitat for Karner blue butterfly and Kirtland warbler, and manage pine, oak

savanna, and dry sand prairie ecosystems. An average of 3,000 to 10,000 acres (1,214 to 4,047 ha) are managed annually through the use of prescribed burns on the HMNF (USDAFS 2003a cf. USFWS 2003).

Past and Current Conservation Activities (Strategies)

Awareness of the plight of the barrens community types has increased significantly in the last ten years. The Environmental Protection Agency has sponsored several conferences that focused on the Midwest oak savanna and woodland ecosystems. Many scientists involved with these conferences collaborated on assembling the Midwest Oak Ecosystems Recovery Plan: A Call to Action (EPA 1995), which provides a synopsis of the current understanding and status of oak community types in the Midwest and the strategies necessary for their recovery. Managers at all levels are starting to emphasize a landscape approach to long term restoration and management plans. Considerable effort has been given by State and Federal agencies and conservation organizations to catalogue and assign quality rankings to existing barrens in the Great Lakes and Midwest regions. Many extant barrens are under public ownership and is either undergoing to await restoration.

Research and Monitoring

Further regional research and monitoring is needed on the ecology of barrens ecosystems, their role in landscape and species biodiversity, and their general and specific value to society. Examples of potential topics to be considered include:

- Determine the most appropriate restoration technique (i.e. fire, mowing etc) to be employed within each landscape feature.

- Conduct quantitative inventories of rare flora and fauna in core preservation areas, with emphasis on population size and viability.

- Develop rare species recovery/restoration plans that incorporate both single species management and ecosystem biodiversity management.

- Develop population models to assess the viability of rare flora and fauna populations under high, moderate, and low quality conditions of the community type.

- Evaluate the effects of varying fire intervals and intensities on rare species and determine minimum area to maintain refugia during burning.

- Determine the extent of indicator species seedbanks and their viability in various quality barrens.

- Develop sound methods to eradicate invasive plants in openings that have the potential to support barrens flora and fauna.

- Develop interagency information/education outreach programs that explain the importance of barrens and restoration techniques (i.e. fire) to the public.

- Assign economic values associated with the restoration and maintenance of barrens in the landscape.

References

Aaseng, N.E. et al. 1993. Minnesota's Native Vegetation. A Key to Natural Communities: Version 1.5. Minnesota Department of Natural Resources – Biological Report No. 20.

Abrams M.D. and D.I. Dickmann, 1984. Floristic before and after prescribed fire on a jack pine clear-cut site in northern lower Michigan. *Can. J. For. Res*. Vol. 14. 746-749.

Abrams, M.D. et al. 1985. Multiple successional pathways on recently disturbed jack pine sites in Michigan. *Forest Ecology and Management*, 10, 31-48.

Albert, D.A. 1995. Regional Landscape Ecosystems of MI, MN, and WI: A Working Map and Classification. USFS-North Central Forest Experiment Station. St. Paul, MN 250 pp.

Allen, T.J. and B. Van Dam. 1993. Element stewardship abstract for southern grizzled skipper (*Pyrgus wyandot*). The Nature Conservancy. 13 pp.

Anderson, R.C. and M.L. Bowles. 1999. Deep-Soil Savannas and Barrens of the Midwestern United States. pp. 155-170. in Savannas, Barrens, and Rock Outcrop Communities of North America. Anderson R. C., J Fralish, and J. Baskin (eds.). Cambridge University Press. 470 pp.

Anderson, R.C. and J.E. Schwegman. 1991. Twenty years of vegetational change on a southern Illinois barren. Natural Areas Journal 11(2): 100-107.

Anderson, R.C. and L.E. Brown 1983. Comparative Effects of Fire on Trees in a Midwestern Savannah and Adjacent Forest. *Bull Torrey Bot. Club* 1:8790

Anderson, R.C. and L.E. Brown, 1986. Stability/Instability after fire. *American Journal of Botany* Vol. 73.

Bacone, J. et al. 1994. Midwest Oak Ecosystem Recovery Plan. 1994 Midwest Oak Savanna Conferences. U.S. Environmental Protection Agency.

Bliss, P. 1987. Element stewardship abstract for regal fritillary (*Speyeria idalia*). The Nature Conservancy. 11 pp.

Bray, J.R. 1960. The composition of savanna vegetation in Wisconsin. *Ecology* 41: 721-732.

Brosofske, K. 2001. Understory vegetation and site factors: Implications for a managed Wisconsin landscape. *Forest Ecology and Management*. 146(1-3): 75-87.

Cayford, J. H. and D. J. McRae. The ecological role of fire in jack pine forests. In: Wein, Ross W., D. A. MacLean, eds. The Role of Fire in Northern Circumpolar Ecosystems. New York: John Wiley and Sons; 1983: 183-199.

Chapman K.A. et al. 1995. Ecology and stewardship guidelines for oak barrens landscapes in the upper Midwest. 1993 Proceedings of the Midwest Oak Savanna Conferences. U.S, Environmental Protection Agency.

CNF 2003. Chequamegon National Forest Land and Resource Management Plan 2003. web site: www.fs.fed.us/R9/CNNF/natres/plan

Cochrane, T.S. and H.H. Iltis. 2000. Atlas of the Wisconsin Prairie and Savanna Flora. Technical Bulletin No. 191. Department of Natural Resources.

Cohen, J.G. 2001. Natural community abstract for oak barrens. Michigan Natural Features Inventory, Lansing, MI. 8 pp.

Cohen, J.G. 2000. Natural community abstract for oak-pine barrens. Michigan Natural Features Inventory, Lansing, MI. 6 pp.

Comer P.J. 1996. Natural community abstract for pine barrens. Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Comer, P.J. 1995. Newaygo Prairies Research Natural Area: Monitoring Plan for Rare Plant Species and Dry Sand Prairie. Report to the Huron-Manistee National Forests. Michigan Natural Features Inventory report 1995-05. 10 pp.

Comer, P.J. 1997. Frost pocket pine barrens management plan (draft). Grayling Forest Area, Au Sable State Forest. Michigan Natural Features Inventory. Lansing, MI. 12 pp.

Comer, P.J. and M.L. Rabe. 1994. Restoration of Oak-Pine Savanna Aids Karner Blue Butterfly (Michigan). *Restoration and Management Notes*. 12(1):103. Michigan Natural Features Inventory report number 1994-06.1994-06.

Corner, R.A., and D.A. Albert. 1999. Landtype Associations of the Manistee Subsection: Subsection VII.4. Prepared for the Northern Lower Michigan Ecosystem Management Project. Michigan Natural Features Inventory report number 1999-05. 84 pp.

Curtis, J.T. 1959. The Vegetation of Wisconsin. University of Wisconsin Press, Madison. 657 pp.

Cuthrell, D.L. 2001. Special animal abstract for *Hesperia ottoe* (Ottoe skipper). Michigan Natural Features Inventory. Lansing, MI. 3 pp.

Drake, J. and D. Faber-Langendoen. 1994. Re-analysis of the pine barrens of Wisconsin. In 1994 Proceedings of the Midwest Oak and Savanna Conferences. U.S. Environmental Protection Agency.

Dunevitz, H. 1993. Characterization of Midwestern oak savannas. 1993 Proceedings of the Midwest Oak Savanna Conferences. U.S, Environmental Protection Agency.

Dunn, J.P. et al. 2002. Distribution, seasonal cycle, host plant records, and habitat evaluation of a Michigan threatened insect: the Great Plains spittlebug, *Lepyronia gibbosa* (Homoptera: Cercopidae). *The Great Lakes Entomologist*. Vol. 35, No.2 121-129.

Dunne, J.P., C.J. Summerfield, M. Johnson, and H. Hereau. September 2002. *Newsletter of the Michigan Entomological Society* 47:4.

Edinger, G.J. et al. 2002. Draft Ecological Communities of New York State. New York Natural Heritage Program www.dec.state.ny.us/website/dfwmr/heritage/Draft

Epstein, E. et al. 2001. The Wisconsin Natural Heritage Inventory's recognized Natural Communities - Working Document.

Evers, D. C. 1994. Endangered and Threatened Wildlife of Michigan. The University of Michigan Press. Ann Arbor, MI. 412 pp.

Faber-Langendoen, D. and M. Davis. 1995. Effects of fire frequency on tree canopy cover at Allison Savanna East central Minnesota, USA. *Natural Areas Journal* 15: 319-328.

Forman, R.T. (ed.). 1979. Pine Barrens: Ecosystem and Landscape. Academic Press, New York, New York. 601 pp.

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada: Second Edition/ The New York Botanical Gardens. New York. 910 pp.

Haack, R.A. 1993a. Ottoe skipper. USDA Forest Service, North Central Forest Experiment Station. East Lansing, MI.

Haack, R.A. 1993b. Phlox moth (*Schinia indiana*) Smith. USDA Forest Service, North Central Forest Experiment Station. East Lansing, MI.

Haack, R.A. 1993c. Southern grizzled skipper. USDA Forest Service, North Central Forest Experiment Station. East Lansing, MI. 2 pp.

Haney, A. and S.I. Apfelbaum. 1995. Characterization of Midwestern oak savannas. 1993 Proceedings of the Midwest Oak Savanna Conferences. U.S, Environmental Protection Agency.

Hause, R.S. 1953. An Ecological Analysis of the Isolated Prairies of Newaygo County. Michigan State University Dissertation.

Heikens, A.L. and P.A. Robertson 1994. Barrens of the Midwest: A review of the literature. *Castanea* 59(3) 184-194.

Heinselman, Miron L. 1981. Fire and succession in the northern conifer forests of northern North America. In West, C. Darrell, H. H. Shugart, D. Botkin, eds. Forest Succession Concepts and Application. New York: Springer-Verlag. 1981. 517 pp.

Higman, P.J. and M.R. Penskar. 1996a. Special plant abstract for *Prunus alleghaniensis* var. *davisii* (Alleghany plum). Michigan Natural Features Inventory, Lansing, MI. 2 pp.

Higman, P.J. and M.R. Penskar. 1996b. Special plant abstract for *Agoseris glauca* (pale agoseris). Michigan Natural Features Inventory, Lansing, MI. 2 pp.

Higman, P.J. and M.R. Penskar. 1996c. Special plant abstract for *Festuca scabrella* (rough fescue). Michigan Natural Features Inventory, Lansing, MI. 2 pp.

Higman, P.J. and M.R. Penskar. 1999. Special plant abstract for *Cirsium hillii* (Hill's thistle). Michigan Natural Features Inventory, Lansing, MI. 2 pp.

Homoya, M.A. 1994a. Barrens: An ecological term: an overview of usage in scientific literature. 1994 Proceedings of the Midwest Oak Savanna Conferences. U.S, Environmental Protection Agency.

Homoya, M.A. 1994. Indiana Barrens: classification and description. *Castanea* 59: 204-213.

HMNF 2003a. Huron-Manistee National Forest Species Viability Evaluation for Need for Change Forest Plan Revision Work-in-Progress Information (internal document).

HMNF 2003b. Huron-Manistee National Forest species viability evaluation database. Prepared by Michigan Natural Features Inventory. Lansing, MI.

HMNF 2003c. Huron-Manistee National Forest document occurrence maps for Forest Sensitive Species.

HMNF 2003d. Huron-Manistee National Forest plan revision – RFSS guidelines. Web site: www.fs.fed.us/r9/hmnf/pages/planforest

Hutchison, M.D. 1994. The barrens of the Midwest: an historical perspective. *Castanea* 59(3): 195-203.

Kline V.M. and T. McClintock, 1994. Changes in a dry oak forest after a third prescribed burn. 1994 Proceedings of the Midwest Oak Savanna Conferences. U.S, Environmental Protection Agency.

Leach, M.K. and L. Ross (eds.) 1995. Midwest oak ecosystems recovery plan: a call to action. 1995 Proceedings of the Midwest Oak Savanna Conferences. U.S, Environmental Protection Agency.

Legge, J.T. 1995. Species information on Sprague's pygarctic (*Pygarctica spraguei*). Michigan Natural Features Inventory. Lansing, MI. 2 pp.

Legge, J.T., P.J. Higman, P.J. Comer, M.R. Penskar, and M.L. Rabe. 1995. A floristic and Natural Features Inventory of Fort Custer Training Center, Augusta, Michigan. Michigan Natural Features Inventory. Lansing, MI. 151 pp.

Little, S. 1979. Fire and plant succession in the New Jersey pine barrens. In Forman, R.T. (ed.). 1979. Pine Barrens: Ecosystem and Landscape. Academic Press, New York, New York. 601 pp.

McCarty, K. 1993. Restoration in Missouri Savannas. 1993 Proceedings of the Midwest Oak Savanna Conferences. U.S, Environmental Protection Agency

McPherson, G.R. 1997. Ecology and Management of North American Savannas. The University of Arizona Press, Tucson, AZ. 208 pp.

Michigan Natural Features Inventory. 1990. Species information on Phlox moth (*Schinia indiana*). Draft. Lansing, MI. 4 pp.

Michigan Natural Features Inventory. 2003. Michigan's Natural Communities Draft List and Description. Lansing, MI. 36 pp.

Minc, L.D. and D.A. Albert. 1990. Oak-dominated communities of southern Lower Michigan: floristic and abiotic comparisons. A report to Michigan Natural Features Inventory. Michigan Natural Features Inventory Report number 1990-05. 103 pp.1990-05.

Mustard, T.S. 1979. The distribution and ecology of *Agoseris glauca* in Michigan with recommendations for mitigation of future impacts. Unpub. Report prepared for the Michigan DNR. 37 pp.

Nature Serve 2003. web site. http://www.natureserve.org/explorer.

Nielsen, M.C. 1999. Michigan Butterflies and Skippers: A Field Guide and Reference. MSU Extension, Michigan State University. 248 pp.

NPWRC 2003. Northern Prairie Wildlife Research Center. Butterflies and Moths of North America. web site. http://www.npwrc.gov/resource.

Nuzzo, V.A. 1985. Extent and Status of Midwest Oak Savanna: presettlement and 1985. *Natural Areas Journal* 6(2):6-36

Olson, S. 2002. Conservation Assessment for Barrens and Glades Natural Communities (draft). USDA Forest Service, Eastern Region. Shawnee National Forest.

Packard, S. and C.F. Mutel (ed.). 1997. The Tallgrass Restoration Handbook For Prairies, Savannas, and Woodlands. Island Press. Washington, D.C. / Covelo, CA. 463 pp.

Panzer, R. 1988. Managing Prairie Remnants for Insect Conservation. *Natural Areas Journal* 8(2):83-90

Penskar, M.R. 1997. Rangewide status assessment of *Cirsium hillii* (Canby) Fern. Michigan Natural Features Inventory. Lansing, MI. 10 pp.

Pregitzer, K.S. and S.C. Saunders. 1999. Jack Pine Barrens of the Northern Great Lakes Region. pp. 1343-361. in Savannas, Barrens, and Rock Outcrop Communities of North America. Anderson R. C., J Fralish, and J. Baskin (eds). Cambridge University Press. 470 pp.

Rabe, M.L., P.J. Comer and D.A. Albert. 1993. Enhancing habitat for Karner blue butterfly: In 1993 *Proceedings of the Midwest Oak Savanna Conference.* Chicago, Illinois.

Radeloff, V.C., D.J. Mladenoff, K.L.Manies, M.S Boyce. 1998. Analyzing forest landscape restoration potential: pre-settlement and current distribution of oak in the Northwest Wisconsin pine barrens. *Transactions* Volume 86. 189-205.

Radeloff, V.C., et al. 1999. Forest landscape change in the northwestern Wisconsin pine barrens from pre-European settlement to the present. *Can. J. For. Res*. 29: 1649-1659.

Radeloff, V.C., D.J. Mladenoff, and M.S. Boyce. 2000. A historical perspective and future outlook on landscape scale restoration in the northwest Wisconsin pine barrens. *Restoration Ecology*. 8(2): 119-126.

Reschke, C. 1990. Ecological Communities of New York State. New York Natural Heritage Program. N.Y.S. Department of Environmental Conservation. pp. 95

Stearns, F. and N. Kobriger. Environmental status of the Lake Michigan Region. Volume 10. Vegetation of the Lake Michigan drainage basin. Argonne National Laboratory, Argonne, Illinois. 1975. 113 pp.

Stebbins, S. 2001. Regional Forester Sensitive Species Reference Guide (draft) Huron-Manistee National Forest (internal document). 14 pp.

Temple S. 1994. Status of rare animals associated with Midwestern oak savannas and woodlands. 1994 Proceedings of the Midwest Oak Savanna Conferences. U.S, Environmental Protection Agency.

Tester, J.R. 1989. Effects of Fire Frequency on Oak Savanna in East Central MN. *Bull Torrey Bot. Club*. 116: 134-144.

USDA 2002. Research Natural Areas Program. North Central Research Station. Web site www.ncrs.fs.fed.us/rna/rnalist

USFWS 2003. U.S. Fish and Wildlife Service biological opinion on the programmatic biological assessment of the Huron Manistee National Forest Land and Resource Management Plan (January2003). website: www.fs.fed.us/r9/hmnf/pages/biologicalopinion

Vogl, R.J. 1970. Fire and the northern Wisconsin pine barrens. *Proceedings of the Tall Timbers Fire Ecology Conference* 10:175-209.

Vora, R.S. 1993. Moquah barrens: Pine barrens restoration experiment initiated in Chequamegon National Forest. *Restor. and Mgmt. Notes* 11(1):39-44

Voss, E.G. 1985. Michigan Flora Part II: Dicots (Sauruaceae-Cornaceae). Bull. Cranbrook Inst. Sci. 59 and U. of Mich. Herb. xix. 724 pp.

Whitney, G.G. 1986. Relation of Michigan's presettlement pine forests to substrate and disturbance history. *Ecology* 67(6):1548-1559.

Will-Wolf S. and F. Stearns. 1999. Dry Soil Oak Savanna in the Great Lakes Region. pp 135-154. in Savannas, Barrens, and Rock Outcrop Communities of North America. Anderson R. C., J Fralish, and J. Baskin (eds). Cambridge University Press. 470 pp.

Wisconsin Department of Natural Resources, 1995. Wisconsin's Biodiversity as a Management Issue: A report to Department of Natural Resource Mangers.

Wowcha, D.S. Minnesota's St. Croix River Valley and Anoka sandplain: a guide to native habitats. 72-77.

Zimmerman, D.A. 1956. The Jack pine association in the lower peninsula of Michigan: Its structure and composition. PhD Thesis. U. of Mich., Ann Arbor, MI

List of Contacts

Region 9 National Forests:

Chequamegon-Nicolet: Steve Spikerman; sspickerman@fs.fed.us
Chippewa: Ray Newman; rwnewman@fs.fed.us;
Green Mountain-Finger Lakes; Marybeth Deller: mdeller@fs.fed.us
Hoosier: Kirk Larson; kwlarson@fs.fed.us
Midewin: Eric Ulaszek; eulaszek@fs.fed.us
Ottawa: Susan Trull; strull@fs.fed.us
Ottawa: Brian Bogaczyk; bbogaczyk@fs.fed.us
Shawnee: Elizabeth Shimp; eshimp@fs.fed.us
Superior: Jack Greenlee; jackgreenlee@fs.fed.us
White: Leighlan Prout; lprout@fs.fed.us
Huron Manistee: Alix Cleveland; acleveland@fs.fed.us
Huron Manistee: Rex Ennis; kennis@fs.fed.us
Huron Manistee: Joe Kelly; jbkelly@fs.fed.us
Huron Manistee: Greg Schmidt; gjschmidt@fs.fed.us

Michigan Natural Features Inventory:

Mike Kost; kostma@michigan.gov
Josh Cohen-Ecologist; cohenjo@michigan.gov
Phyllis Higman; higmanp@michigan.gov
Dave Cuthrell; cuthrelld@michigan.gov

Department of Natural Resources:

Dave Smith (MI); 989-785-4251
John Lerg; (MI); lergj@michigan.gov
Ron Eckstein (WI); 715-365-8999
Pat.Swain (MA) patswain@state.ma.us

The Nature Conservancy:

Jack McGowan-Stinski; jmcgowan-st@TNC.ORG

Additional:

Mo Nielson: (butterflies and skippers); nielsen4@msu.edu
James Dunn: (spittlebugs); dunnj@gvsu.edu