North Camp Grayling
Pine Barrens Management Plan

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INTRODUCTION

This project represents a cooperative effort between the Michigan Department of Military Affairs (DMA), Michigan Department of Natural Resources (DNR) and Michigan Natural Features Inventory (MNFI) to restore a globally and locally rare (G2/S2), pine barrens ecosystem to North Camp Grayling. The management and monitoring plan presented in this report aims to restore a functioning pine barrens ecosystem where natural processes can play a significant role in shaping community structure. The plan is intended to serve as a catalyst and guide for creating and maintaining a functioning pine barrens ecosystem that includes the following components:

- large, open grass- and sedge-dominated areas
- small, isolated patches of dense jack pine
- scattered, dead, standing trees or "snags"
- a structurally diverse tree layer
- healthy populations of native plants and animals, including rare species

The project has involved conducting inventories for rare plant and animal species, characterizing the avian community, and performing an assessment of management actions needed for restoring a functioning pine barrens ecosystem to the area. This area was originally identified as the "Pine Barrens Opportunity Area" in a floristic and natural features inventory of Camp Grayling (Higman et al. 1994) and is referred to here as the North Camp Grayling Pine Barrens Management Area. Most of the lands covered by this project are managed by the DNR and are leased, for training purposes, to the DMA. The lands contained within the fenced, Multipurpose Range Complex (MPRC), comprising approximately 18% of the management area, are leased and managed by the DMA. The entire area outside of the MPRC is open to the public for recreational use except during active military training.

This project was conceived and developed to be compatible with certain types of military training. These include activities that will allow the open character of the pine barrens to be maintained without disturbing the soil. The management area contains several state listed plant species that are likely to be adversely affected by significant soil disturbances either directly through uprooting or indirectly as a result of competition from aggressive alien species such as spotted knapweed (*Centaurea maculosa*). A primary cause of soil disturbances in the Camp Grayling area is the off-road use of tracked vehicles. As stated in a previous MNFI report for Camp Grayling, tracked vehicle use which is restricted to designated tank trails is likely to be compatible with the restoration and maintenance of a healthy pine barrens ecosystem (see pg. 96, Higman et al. 1994). Because of the sensitivity of state-listed species, activities resulting in significant soil disturbance will require consultation with the state Endangered Species Coordinator, Wildlife Division, DNR, and may require an endangered species permit.

PINE BARRENS OVERVIEW

Pine barrens in the Upper Great Lakes region are described as open savannas with vegetation dominated by grasses, forbs, shrubs, and open-grown trees (Curtis 1959, Vogl 1970, Whitney 1986). They most often occur on glacial outwash deposits of well drained to excessively drained sands. Landscapes historically supporting pine barrens were among the most fire-dominated areas in the Great Lakes region (Simard & Blank 1982, Whitney 1986). Dry lightning events and Native American activities were the main sources of fire prior to European settlement in the region. Droughty soil conditions and an absence of natural fire breaks allowed wildfires to frequently burn over large areas.

Today, in several locations in the High Plains region of northern Lower Michigan, pine barren remnants are located in depressions or outwash channels formed by post-glacial drainage. Soils of these channels are often excessively drained, gravelly sands. Because of their lower topographic position, these areas drain cold air from the surrounding landscape, so frost conditions are common and quite severe, even during the growing season (Palmgren 1999, Walker 1999). This combination of frequent

wildfire and frost action resulted in a patchwork of open grass and shrubland with trees clustered in groups or as isolated individuals. In his study of presettlement conditions in Crawford and Roscommon counties, Whitney (1986) estimated that pine barrens occurred in patches ranging in size from 40-7,000 acres. The combination of frequent wildfire and frost conditions created the vegetation mosaic we call pine barrens.

Along with other examples in the northern Great Lakes region, remnant pine barrens in northern Lower Michigan and Michigan's Upper Peninsula support a mixture of plant species with affinities to either the mid-western dry, tallgrass prairie or northern pine-dominated forests. In the 1800's Michigan pine barrens typically had a scattered overstory of jack pine (*Pinus banksiana*), with lesser amounts of red pine (*Pinus resinosa*), white pine (*Pinus strobus*), northern pin oak (*Quercus ellipsoidalis*), and quaking aspen (*Populus tremuloides*). Today, common shrub or small tree species include jack pine, black cherry (*Prunus serotina*), sand cherry (*Prunus pumila*), pin cherry (*Prunus pensylvanica*), prairie willow (*Salix humilis*), sweet-fern (*Comptonia peregrina*), blueberry (*Vaccinium angustifolium*), common blackberry (*Rubus alleghaniensis*), and bearberry (*Arctostaphylos uva-ursi*). Grasses, sedges, and forbs characteristic of today's Michigan pine barrens include little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), poverty grass (*Danthonia spicata*), hair grass (*Deschampsia flexuosa*), rice grass (*Oryzopsis asperifolia*), June grass (*Koeleria macrantha*), Pennsylvania sedge (*Carex pensylvanica*), sedge (*Carex lucorum*), prairie cinquefoil (*Potentilla arguta*), northern blazing star (*Liatris scariosa*), smooth aster (*Aster laevis*), and bird's foot violet (*Viola pedata*).

An intensive survey effort conducted by MNFI during 1992-1993 of the jack pine barrens in the High Plains region revealed that although pine barrens persist as fragmented remnants, they continue to harbor significant populations of several rare plants including the state threatened (T) rough fescue (*Festuca scabrella*) and pale agoseris (*Agoseris glauca*), and state special concern (SC) Alleghany plum (*Prunus alleghaniensis*) and Hill's thistle (*Cirsium hillii*) (Higman et al 1994). Both pale agoseris and rough fescue are disjunct in Michigan from their primary ranges in western North America, and are restricted in Michigan to the jack pine barrens of the High Plains region of the central northern Lower Peninsula. Alleghany plum is also disjunct in Michigan from its primary range in the eastern United States. Michigan populations are considered an endemic variety (*Prunus alleghaniensis* var. *davisii*) and occur primarily in the pine barrens of the High Plains region and to the southwest in prairies and oak-pine barrens of the Newaygo Outwash Plain. In contrast, populations of Hill's thistle in the pine barrens of the High Plains region represent a stronghold of this species lying in the center of its larger Great Lakes range. The High Plains populations of these rare species are an important component of the biodiversity of northern Lower Michigan. Associated with a fire-dependent landscape, these plants are expected to benefit from the reintroduction of fire to the pine barrens ecosystem.

Several rare animal species are also associated with Michigan pine barrens. Historically, federal and state endangered Kirtland's warbler (*Dendroica kirtlandii)* was found nesting within the dense jack pine thickets that occurred within or adjacent to open pine barrens. The state endangered prairie warbler (*Dendroica discolor*) also nests among clusters of shrubs and trees in these habitats. The state special concern black-backed woodpecker (*Picoides arcticus*) may also be found in pine barrens. This species relies on fires and other natural disturbances to create dead standing trees with loose bark, which it utilizes for foraging and nesting habitat. Michigan pine barrens are also known to support rare insects such the dusted skipper (*Atrytonopsis hianna*) (T), blazing star borer moth (*Papaipema beeriana*) (SC), and secretive locust (*Appalachia arcana*) (SC), a Michigan endemic.

In the 1800's, prior to the logging era, approximately 205,000 acres of Lower Michigan supported pine barrens (Comer et al. 1995). Slash fires resulting from logging probably expanded the total acreage of these plant

communities early in the 20th century, but subsequent land use greatly altered pine barrens composition and structure, and reduced their acreage to a small fraction of historical levels. Large diameter red and white pines were removed from many pine barrens during the logging era. Due to their open condition, pine barrens were sometimes utilized for homesteads and grazing. These activities, along with road construction, allowed for the introduction of many invasive, non-native plant species such as spotted knapweed, Canada bluegrass (*Poa compressa*), and hawkweed (*Hieracium* spp.). In a number of places, mostly on public land, red pine and jack pine plantations were established in areas once supporting pine barrens.

Wildfire suppression since the 1920's has probably had the greatest effect on pine barrens, allowing extensive areas to succeed to closed-canopy mixed-pine forest. As a result, many of the shade-intolerant plant species with affinities for prairie communities have been shaded out of these areas. Even in places where a shrub and tree canopy has not completely closed in, herbaceous plant species diversity has often declined significantly. Cope (1992) found that in the absence of fire, Pennsylvania sedge tended to aggressively form clones and dominate, thus lowering species diversity. However, sedge density was found to decrease considerably following prescribed burns at the Shakey Lakes barrens in Menominee County (D.A. Albert pers. comm.).

Because of this land use history, it is important to identify opportunities where Michigan pine barrens remnants can be restored and maintained. This should involve portions of public land where fire can be re-introduced in a controlled fashion. Systematic survey work by MNFI identified a number of sites on state and federal land throughout northern Lower Michigan and the Upper Peninsula where pine barren remnants occur among large blocks of public land. Pine barrens ecosystem management is now underway within the Grayling Forest Management Unit (Comer 1997), and Huron National Forest (Huron-Manistee National Forest 1996). Similar efforts have also taken place in Wisconsin (Vora 1993). The North Camp Grayling management area is an ideal location for pine barrens ecosystem management as it is publicly owned, contains high quality pine barrens remnants, and harbors several rare plant and animal species. (For more detailed information on the pine barrens community, associated rare species, ecoregional context see Appendicies 1 and 2).

SITE OVERVIEW

SITE LOCATION

The North Camp Grayling Pine Barrens Management Area is located in north central Crawford County, on the Camp Grayling Military reservation, within the Grayling Forest Management Unit administered by the DNR, Forest Management Division. The total acreage of the pine barrens management area is approximately 5,120 acres (2,073 ha). The area is divided into seven management units, several of which have been further divided into sub-units, based on vegetation structure and available firebreaks (Figure 1 and Appendix 3). *Legal Description*: T27N, R2W sections 7, 8, 9, 10, 15, 16, 17, 18.

CURRENT AND PROJECTED USE

The area is currently managed to provide for military training, wildlife habitat, forest products and public recreation. Use of this area by the DMA for military training is expected to continue, and may even increase, as grassland habitat increases. Military training activities that do not disturb the soil are likely to be compatible with successful restoration and maintenance of a pine barrens community. Although recent tracked and wheeled off-road vehicle use within the management area appears minimal, this may change as tree cover is reduced. Activities that cause soil turnover, such as off-road tracked vehicle use, would likely result in degradation and unsuccessful maintenance of the community. Military training within the management area

also includes aircraft drops of cargo and soldiers into the Miller Drop Zone (Unit 7). Tracked vehicles are restricted from entering this area. The Miller Drop Zone will continue to be managed as open grassland. As management progresses more openings will be created benefiting game species such as white-tailed deer and ruffed grouse. Although the area is not highly productive, forest products are extracted from the area. This use will decline once the area is restored to pine barrens. Public recreation activities include hunting and snowmobiling and are currently permitted outside of the fenced MPRC (Unit 4), except during military training exercises. Public recreational use of the area is fully compatible with pine barrens management and hunting opportunities are expected to increase.

ECOREGIONAL CONTEXT

The management area is located within the Grayling Outwash Plain sub-subsection of the regional landscape ecosystems described by Albert (1995). This area is a high outwash plain and contains several large moraines of ice-contact material (Albert 1990). The management area occurs in an outwash channel and borders an area of ice-contact to the west. Topography of the management area is nearly level in the central and eastern portions and becomes rolling in the west, where ice-block depressions are common. The soils are primarily excessively well drained Graycalm-Grayling sands and Graycalm sands. The Grayling Outwash Plain Sub-subsection experiences some of the most extreme climatic conditions in the Lower Peninsula, with below freezing temperatures occurring throughout the growing season, especially within ice-block depressions (Palmgren 1999). A more detailed description of the region can be found in the Landtype Associations on the High Plains: Subsection VII.2, by Corner and Albert (1999). (A copy of the landtype association descriptions found within the management area is included in Appendix 2).

HISTORICAL CONDITIONS

The earliest records of vegetation in the Camp Grayling Management Area are from the General Land Office (GLO) surveys conducted in the mid-1800's (Figure 2). Surveyors generally described the area as "gently rolling burnt land" with vegetation along section lines noted as "large and small pines" and "thickets of jack pine with scattered red pine". Comments by the early GLO surveyors such as "pine poles killed by fire", "jack pine nearly all killed by fire", and "timber burnt, dead" make it clear that fire played a major role in shaping the North Camp Grayling pine barrens ecosystem. These descriptions illustrate an open ecosystem of fire-adapted species, containing widely scattered, uneven-aged red and white pines, dense thickets of jack pine, and many dead standing trees or snags.

As the surveyors moved across the state they recorded specific information along each section line and section corner. At each section corner they measured the distance to the two nearest trees from opposing quadrats (e.g., northwest and southeast) and also recorded their species and diameter. Distances of witness trees from section corners varied considerably, with small clusters of trees apparent at some section corners, while at others only one tree was close enough to be used as a witness. Analysis of the GLO notes for the management area reveals that at the time of the survey jack pine, red pine, and white pine were almost equally abundant (Figure 3). However, the species were distributed across the landscape in very different patterns. Jack pine was found growing in dense thickets of varying height classes (large, 20-30 ft tall; and small, 4-6 ft tall) and red pine and white pine, while also showing size class variation (12-24, and 6-30 inches in diameter, respectively), were noted as widely scattered individuals. White oak, northern pin oak, and aspen were also occasionally reported as witness trees.

CURRENT CONDITION

From information provided by the GLO surveyors it appears that the North Camp Grayling Management Area was once part of a patchy mosaic of open pine barrens and jack pine-red pine forest that encompassed more than 160,000 acres in the mid 1800's (Comer et al.

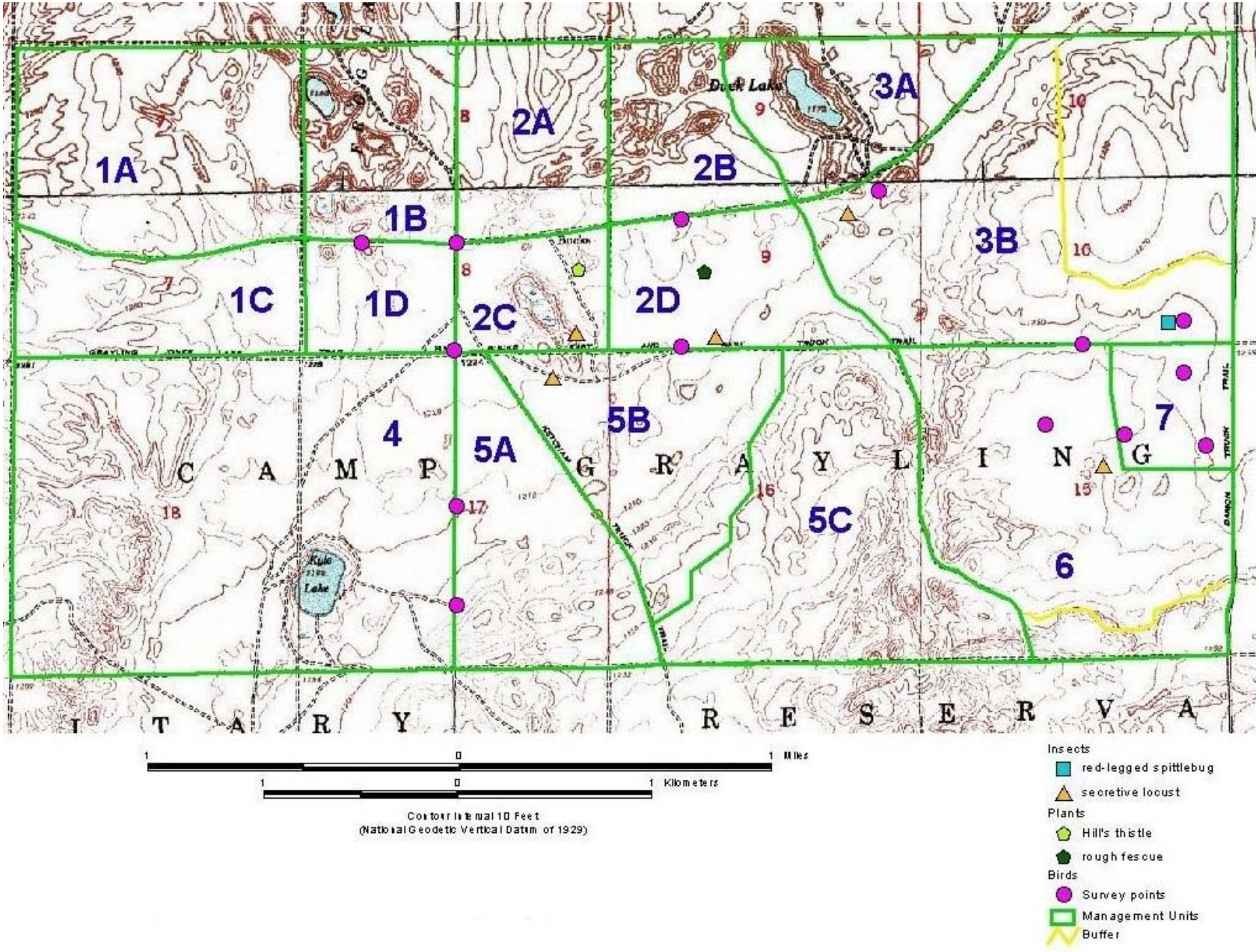

Figure 1. Management units and sub-units for North Camp Grayling Pine Barrens Management Area.

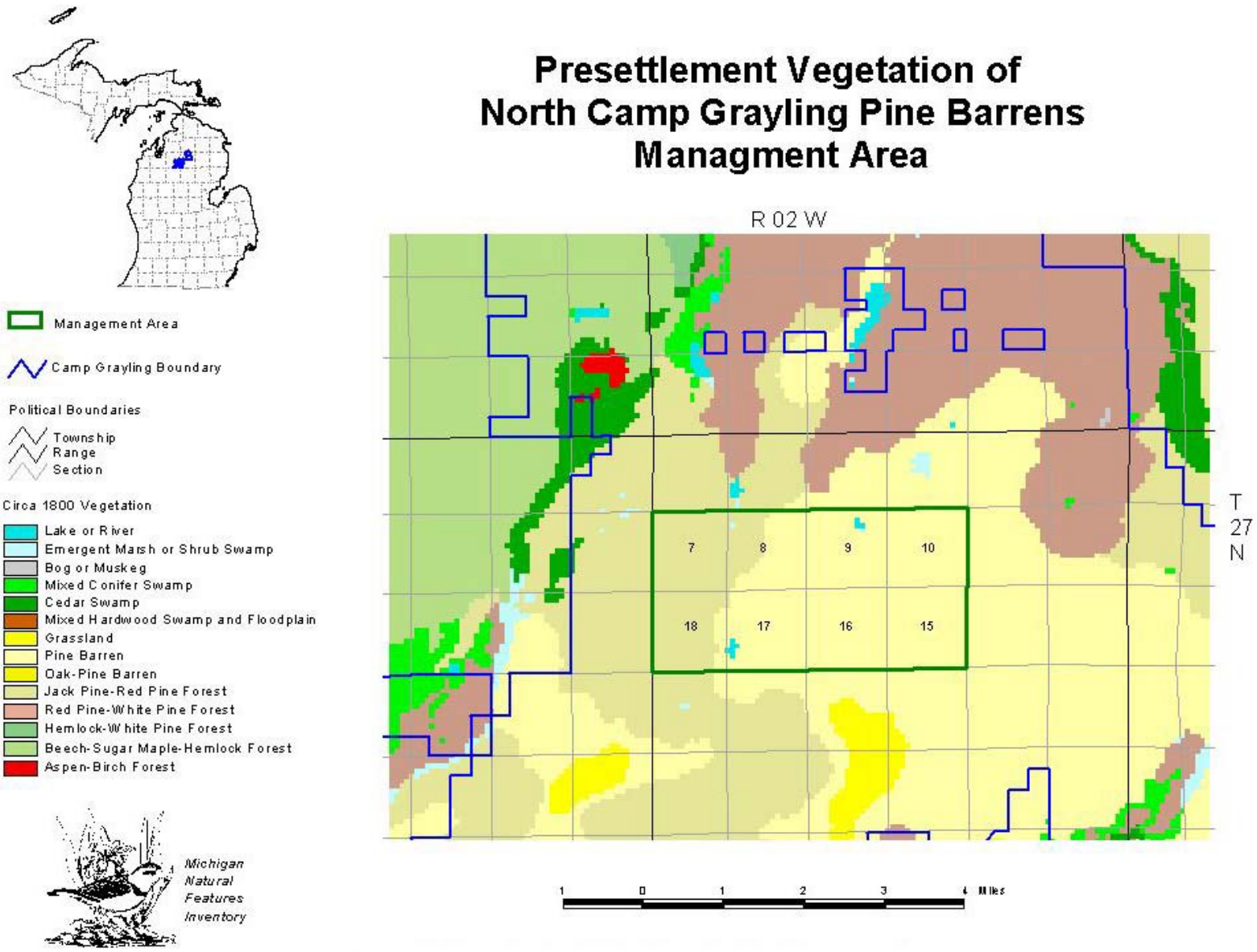

Figure 2. Vegetation circa 1800 of North Camp Grayling Management Area (Comer & Albert 1998).

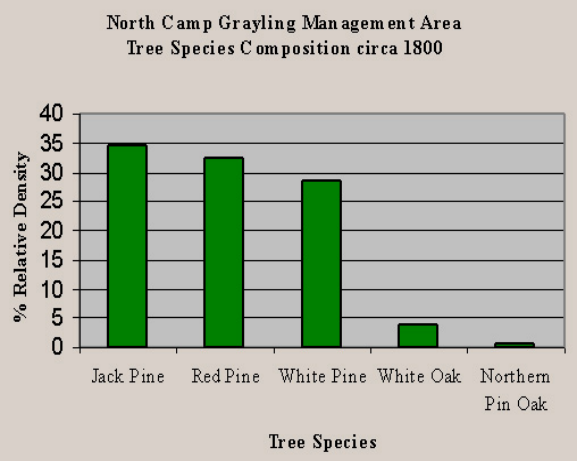

Figure 3. Percent relative density of tree species from GLO records for section corners and section lines T27N, R02W, sections 7-10 and 15-18.

1995). Remnants of this extensive pine barrens continue to exist there today. Much of the vegetation cover within the management area consists of pine barrens that are rapidly succeeding to jack pine forest. Where this process of canopy closure is complete, there are dense patches of jack pine forest with little groundcover. Conversely, the openings support a thickly vegetated patchwork of grasses, sedges, forbs, and low shrubs. Rare plant species such as rough fescue and Hill's thistle may be abundant within the open pine barrens remnants, but seldom occur under the dense shade of the jack pine forests. Along the margins of several of the larger jack pine forest patches are small aspen groves. Dry-mesic forests of white oak and northern pin oak occur near the edges of the management area. Their understories are filled by red maple and black cherry and no evidence of oak recruitment was seen. The bracken-fern dominated ground layer and a thick mat of partially decomposed leaves allows for little plant diversity and directly inhibits species recruitment from the seed bank (Facelli & Pickett 1991, van der Valk 1986).

SITE INVENTORIES

VEGETATION AND RARE PLANT INVENTORIES

The North Camp Grayling Management Area was explored during the summer of 1998 in order to collect information useful for designating individual management units and to qualitatively assess the distribution of rare plant species. Meander surveys were used and attempted to cover as much variation in the habitat as possible. Each plant species and an estimate of its abundance were recorded for each area surveyed (Appendix 4). For rare plants, the number of individuals or localized colonies was tallied and an overall estimate of cover (m^2) for each occurrence was recorded. Additional characteristics of the landscape, such as soils, geological features, topography, and the occurrence of wetlands were also noted.

Of the four rare plant species with the highest potential for occurrence at the site, only two were found, rough fescue and Hill's thistle (Table 1). Localized colonies of rough fescue were observed in all management units except Unit 3. The largest colonies were found within expansive openings in Units 1, 2, and 4, corresponding to areas most closely resembling historical pine barrens. Occasional patches as large as 25 m^2 were observed in Unit 2. The few patches of rough fescue within the forested portions of units 5 and 6 are very small, mostly less than 3 m^2, and are restricted to canopy gaps. Hill's thistle was observed only rarely within the management area. Individual plants were found throughout the more open portions of Units 1, 2, 4, 5 and 7. Pale Agoseris and Alleghany plum were not found during our survey although they do occur in other similar habitats of the High Plains region. The closest known, extant occurrence of pale agoseris is in a remnant pine barrens in the Shupac Lake area, approximately 8 miles to the northeast. Alleghany plum has been documented in several places within a 1/2 mile of the management area.

Table 1. Summary of rare plant occurrences by management unit.

Unit	1	2	3	4	5	6	7
Rough Fescue	X	X		X	X	X	
Hill's Thistle		X		X	X		X

RARE ANIMAL INVENTORIES

The animal surveys had two objectives. First, surveys targeted those endangered, threatened, and special concern animal species which had a high likelihood of occurrence at the site, based on habitat requirements and histories of occurrence in the state. Secondly, surveys were designed to record representative bird species associated with the current vegetation types throughout the proposed management area. This area of the state has been poorly surveyed for the presence of certain animal species, particularly insects. Prior to our work the only rare animal species recorded from the North Camp Grayling Management Area were the Kirtland's warbler and secretive locust.

Birds

Surveys of avian species utilized point counts to determine bird abundance and species richness. Fifteen, 50 m circular plots (Ralph et al. 1995) were systematically placed approximately every ¼ mile along major roads and trails of the management area (Figure 1). Points were systematically placed throughout the study area to reflect the variation in habitat conditions at the study site (Ralph et al. 1995). Surveys were conducted on 9 June 1998 and 26 June 1999 between the hours of 6:30am and 11:00am. Circular plots were sampled by standing in the center of the plot for 5 minutes and counting all birds observed within 50 m of the center of the plot, as well as birds observed beyond 50 m. Birds tallied within 50 m of the center of the plot were used to calculate a relative abundance for each dominant species, expressed as the average number of birds per point (Ralph et al. 1995). A mean species richness, based on the number of birds observed per sampling point, was also calculated for 1998, 1999 and the two years combined.

A total of 24 species were observed during 1998 and 25 species during 1999. Total number of species observed between years was 27, with a 76% overlap in species observed between years (Table 2). Overall avian abundance was low throughout the study area (Table 3). Dominant species observed at the site included the Nashville warbler (*Vermivora ruficapilla*), blue jay (*Cyanocitta cristata*), Lincoln's sparrow (*Melospiza lincolnii*), hermit thrush (*Catharus guttatus*) field sparrow (*Spizella pusilla*), and chipping sparrow (*Spizella passerina*).

Four major habitat types were represented at the site and included jack pine forest (comprising the majority of available habitat), sand prairie, deciduous second growth forest, and early seral hardwood regeneration (deciduous shrub habitat). Jack pine habitat was dominated by the Nashville warbler, blue jay, field sparrow, hermit thrush, and Lincoln's sparrow. The sand prairie in Unit 7 was dominated by the vesper sparrow (*Pooecetes gramineus*), eastern bluebird (*Sialia sialis*), American goldfinch (*Carduelis tristis*), and field sparrow. A pair of upland sandpipers (*Bartramia longicauda*) was also observed each year in the sand prairie (Unit 7). Deciduous shrubby habitat was dominated by generalist species such as the indigo bunting (*Passerina cyanea*), Eastern towhee (*Pipilo erthrophthalmus*), brown thrasher (*Toxostoma rufum*), and chipping sparrow. Some common deciduous forest species observed included the scarlet tanager (*Piranga olivacea*), rose-breasted grosbeak (*Pheucticus ludovocianus*), red-eyed vireo (*Vireo olivaceus*), and ovenbird (*Seiurus aurocapillus*).

No threatened or endangered avian species were documented during the surveys. However, in the past the Kirtland's warbler did occur in several places within the management area (e.g., in section 7, from 1976 - 1984; section 8, 1973 - 1987; section 9, 1972 - 1988, section 15, 1971 - 1977, and section 17, 1971 - 1977). This species typically prefers tree height between 1.7 m and 5 m tall and populations begin to decline when tree heights exceed 3.5 m. At this site the jack pine stands are typically greater than 5 m tall and are therefore unsuitable to the Kirtland's warblers (Brewer et al. 1991).

Table 2. Avian species observed by habitat type during 1998 and 1999 at Camp Grayling.

Species	Jack Pine Forest	Sand Prairie	Oak Forest	Early Seral	Population Trend[1]
American crow (*Corvus brachyrhynchos*)	X				Increasing
American goldfinch (*Carduelis tristis*)	X	X			Decreasing
American robin (*Turdus migratorius*)		X			Stable
Black-capped chickadee (*Poecile atricapillus*)	X		X	X	Increasing
Blue jay (*Cyanocitta cristata*)	X		X		Decrease
Brown thrasher (*Toxostoma rufum*)				X	Decreasing
Cedar waxwing (*Bombycilla cedrorum*)	X				Stable
Chipping sparrow (*Spizella passerina*)	X	X		X	Decreasing
Common nighthawk (*Chordeiles minor*)	X				Increasing
Common raven (*Corvus corax*)	X				Increasing
Dark-eyed junco (*Junco hyemalis*)	X	X			Increasing
Eastern towhee (*Pipilo erthrophthalmus*)				X	Decreasing
Eastern bluebird (*Sialia sialis*)		X			Decreasing
Eastern kingbird (*Tyrannus tyrannus*)					Decreasing
Field sparrow (*Spizella pusilla*)	X	X			Decreasing
Hermit thrush (*Catharus guttatus*)	X				Stable
Indigo bunting (*Passerina cyanea*)	X		X	X	Decreasing
Lincoln's sparrow (*Melospiza lincolnii*)	X	X			Increasing
Mourning dove (*Zenaida macroura*)		X			Increasing
Nashville warbler (*Vermivora ruficapilla*)	X				Increasing
Ovenbird (*Seiurus aurocapillus*)			X		Increasing
Pine warbler (*Dendroica pinus*)	X				Stable
Red-eyed vireo (*Vireo olivaceus*)			X		Increasing
Rose breasted grosbeak (*Pheucticus ludovocianus*)	X		X		Decreasing
Scarlet tanager (*Piranga olivacea*)			X		Stable
Sharp-shinned hawk (*Accipiter stiatus*)	X				Increasing
Song sparrow (*Melospiza melodia*)	X				Decreasing
Upland sandpiper (*Bartramia longicauda*)		X			Decreasing
Vesper sparrow (*Pooecetes gramineus*)		X			Decreasing
Total	18	10	7	5	

[1]Population trend in Michigan from U.S. Fish & Wildlife Breeding Bird Survey.

Table 3. Overall bird abundance, species richness and abundance of dominant avian species[1].

Species	1998 Abundance	1999 Abundance	2-Year Average Abundance
Overall Bird Abundance[2]	3.80 ± 1.20	5.00 ± 1.10	4.40 ± 0.80
Species Richness[3]	4.20 ± 0.89	3.90 ± 0.85	4.00 ± 0.58
Blue jay (*Cyanocitta cristata*)	0.33 ± 0.40	0.46 ± 0.50	0.40 ± 0.30
Nashville warbler (*Vermivora ruficapilla*)	0.60 ± 0.45	0.53 ± 0.46	0.56 ± 0.30
Chipping sparrow (*Spizella passerina*)	1.46 ± 0.62	0.53 ± 0.35	1.00 ± 0.37
Hermit thrush (*Catharus guttatus*)	0.20 ± 0.22	0.13 ± 0.19	0.16 ± 0.14
Field sparrow (*Spizella pusilla*)	0.06 ± 0.14	0.40 ± 0.35	0.23 ± 0.18
Lincoln's sparrow (*Melospiza lincolnii*)	0.20 ± 0.31	0.33 ± 0.45	0.26 ± 0.25

[1]Abundance of dominant species expressed as the average number of individuals observed (within 50 m of observation point) per observation point.
[2]Overall bird abundance expressed as the average number of birds observed (within 50 m of observation point) per observation point.
[3]Average number of species observed per observation point (including species observed beyond 50 m).

Insects

Three rare species of pine barrens associated insects had the potential for occurrence at the Camp Grayling Management Area including the secretive locust, red-legged spittlebug (*Prosapia ignipectus*), and blazing star borer moth. A variety of techniques were used to survey for the presence of these species, including collection with aerial nets, sweep net sampling, searching for host plants, and blacklighting.

Sweepnetting surveys were conducted targeting both the red-legged spittlebug and the secretive locust. Fifteen sampling stations were systematically placed in potential habitat throughout the management area. The spittlebug is known from grassy ridges in or near wetland complexes, and is often associated with little bluestem. Sweep samples were conducted in August of both 1998 and 1999, with 60 sweeps of the sweep net per sampling point (n=15).

In addition to the general sweep samples conducted in August, meander surveys for the secretive locust were conducted during September 15-16, 1998 and September 1-2, 1999 in management units 2, 3, 5, and 6. This involved two people walking through appropriate jack pine barrens habitat and scanning the sunny sides of the jack pine tree trunks for basking secretive locusts.

Host-plant surveys were an important initial step in searching for the blazing star borer moth. The larvae of this moth species feed only on blazing star (*Liatris* spp.). Surveys for the moth were conducted wherever blazing star was found in sufficient quantities to potentially support a population of the insect. Blacklight surveys were conducted at two sites (Units 2 and 3) on September 15-16, 1998 and two sites (Units 2 and 7) on September 1-2, 1999.

Both the secretive locust and red-legged spittlebug were recorded from the Camp Grayling Management Area during 1999 surveys (Figure 1). Three new locations for the secretive locust (Units 2C, 5B, and 6) were documented within the management area and two old sites (Units 2D and 3B) were reconfirmed. One new site for the red-legged spittlebug was discovered in Unit 3B in a small patch of little bluestem. More occurrences for this species will likely be found if sweep-net surveys are continued and focus on patches of little bluestem. No blazing star borer moths were observed during the two-year survey. However, the potential for its occurrence is very likely, as patches of its host plant are found throughout the management area

MANAGEMENT

DESIRED FUTURE CONDITION

The desired future condition of the management area is a pine barrens containing large expanses of open grassland with scattered patches of uneven aged jack pine, red pine, white pine, northern pin oak, and aspen. Ideally, the open grassland would harbor a diverse array of native grasses, sedges, forbs, and woody species. Pine barrens and grassland associated insects and birds would also become increasingly common as management progresses.

To achieve this goal, it will be necessary to reintroduce fire to the pine barrens ecosystem, as well as replant red and white pine. Successful restoration and maintenance of the community will also require that soil disturbances be limited and the spread of spotted knapweed prevented.

MANAGEMENT OBJECTIVES

1. Reduce the cover of jack pine to 30% ($\pm$ 10%) in each of the management units and sub-units.
2. Decrease the size of individual jack pine patches to no more than 10% ($\pm$ 1%) of the area of any management unit and sub-unit.
3. Increase vegetation community structural complexity by planting red and white pine.
4. Reduce the cover of exotics, specifically spotted knapweed in the sand prairie of Unit 7.
5. Increase native animal species diversity and abundance.
6. Maintain or increase native, ground-layer

species diversity.

7. Maintain or increase rare species abundance and frequency.

MANAGEMENT PROTOCOL

Management Units

To facilitate management and help track its progress, the management area has been divided into 7 management units. Because of their large size and the availability of firebreaks (county and logging roads), several of the management units have been further divided into sub-units. (Figure 1 and Appendix 3). The size, in acres, of each unit and sub-unit is given in Table 4.

Burn Schedule

An initial prescribed fire should be conducted in each management unit and sub-units, with an effort made to avoid burning adjacent areas during the same year. Burns should be conducted in the spring, fall, or late summer. Following the initial prescribed fire in a unit or sub-unit, a second burn should be conducted within 3 to 5 years. Because the seeds of jack pine germinate profusely following a fire, it will be important to conduct a second prescribed burn before the seedlings grow to sapling size. Conducting two prescribed burns within several years will reduce the chance of creating dense jack pine thickets and result in increased forb and grass production. If the cover of jack pine has not been significantly reduced following the second prescribed burn, a third burn should be conducted within 5–7 years. Each of the sub-units presently contain areas of dense jack pine and it is likely that a third prescribed burn will be needed in order to create large, open grass- and sedge-dominated areas. As the system begins to approach an open pine barrens, the interval between burns can be reduced to 10-30 years. A proposed burn schedule is presented in Table 4. Following these burns it will be especially important to monitor jack pine seedling distribution. If the frequency of seedlings within a management sub-unit exceeds 40% (e.g., 30% $\pm$10), a follow-up burn should be conducted within 3-5 years. The greatest species diversity will be achieved by conducting prescribed burns under a variety of moisture conditions, and varying the fire return interval and seasonal timing. (See Figures 4 and 5 in Community Monitoring Section for decision-making flow charts.)

In dense jack pine stands, managers may initially choose to create openings by logging instead of burning. If logging is chosen as the desired management option it should be done in winter when the ground is frozen to minimize disturbance to the root zone of ground-layer vegetation. Following the timber cut, prescription burning should be used to boost forb and grass production and maintain an open grass-dominated landscape with scattered pockets of jack pine, red pine, white pine, and northern pin oak. The area should be initially burned within 5 years of logging. A second burn should be conducted within 3-5 years to prevent extensive thickets of jack pine from becoming established. When the desired future condition is reached the burn interval should be lengthened to 10-30 years. Jack pine seedling frequency should be monitored 2-3 years after each burn. If seedling frequency is high (e.g., > 40%), another prescribed burn should be conducted within 3-5 years.

Table 4. Proposed burn schedule.

Unit	Acres	Year*																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1A	393				X			X					X										X				X			X	
1B	202								X			X					X											X			X
1C	238									X				X					X										X		
1D	116			X			X				X											X				X					
2A	198															X			X					X							
2B	209																X			X					X						
2C	126		X			X				X													X				X				
2D	220			X			X					X										X				X					
3A	265					X			X				X															X			X
3B	673										X				X						X									X	
4	901	X			X			X										X													
5A	278															X			X					X							
5B	317																X			X					X						
5C	421																	X			X						X				
6	470				X			X						X										X					X		
7	107		X			X				X												X			X						

*Note: No two adjacent management units or sub-units are proposed for burning within the same year

Planting Red and White Pines

Increasing the vegetation structural complexity of the management area can be accomplished by inter-planting red and white pines. It may not be prudent to plant red and white pines in the initial stages of management because of the difficulty of protecting them from fire. However, once sufficient openings have been established and the time between burns is lengthened to 10-30 years, low numbers of red and white pine should be planted in each of the management units (e.g., in each unit plant 100-200 red pine and 200-300 white pine). Waiting to plant the red and white pines until the burn interval is lengthened will increase their chance of surviving a future fire. The pines can be established by planting seedlings and/or seed. Seedlings should be planted in clusters of 5-20 individuals comprised of either a single species or both species. Seeding can also be done in single or mixed species plantings. In time, a varied age and size structure will result as offspring of the originally planted trees begin to mature. Because white pine requires more mesic conditions than red pine its survival may be further enhanced by planting near the tops of slopes, in hilly ice contact terrain, where soils may be more productive and the incidence of summer frosts are reduced. In addition, white pine is also considered less fire tolerant than red pine. White pine plantings may be best protected from fire when placed near the tops of north and east facing slopes as fires moving with the prevailing westerly winds will reach these leeward areas less frequently. These types of microhabitats occur throughout the management area and can be easily identified on topographic maps. Where feasible, it will be prudent to protect these trees from fires until their lower branches are well above the ground layer vegetation. Efforts to protect the few red pines that remain within the management area from cutting and burning should also be undertaken when feasible. No trees should be planted in the sand prairie of Unit 7.

Spotted Knapweed Removal

Spotted knapweed is an exotic species that has the potential to colonize large open areas. This species thrives on disturbed soil and its occurrence within the North Grayling Management Area follows this pattern. At the time of the survey, spotted knapweed was found growing in the sand prairie in Unit 7, throughout the tank range and near Kyle Lake in Unit 4, and in the eastern portion of Sub-Unit 1B, where a two-track enters the unit from Stephan Bridge Road. Because the infestations in the sand prairie of Unit 7 are restricted to missile holes, it is imperative that they be removed before the plant

becomes established throughout the prairie. Next, the few plants in Sub-Unit 1B should be removed. The population established in the tank range and near Kyle Lake will be difficult to eliminate and efforts here should focus on preventing its spread into the remnant pine barrens in the northeastern portion of the unit (4).

When managing spotted knapweed it is especially important to detect and remove outlying individuals so that new populations are prevented from establishing. Annual walk-through surveys for spotted knapweed should be conducted during the growing season (e.g., June - August) in each of the management units and sub-units. These surveys should concentrate on areas surrounding past and present infestations and where there has been significant soil disturbance. When found, all plants should be removed. Like many other invasive plant species, the occurrence of spotted knapweed is likely to be associated with soil disturbance (e.g., as in the sand prairie and tank range). Therefore, an increase in military maneuvers within the management area may result in an increase in the number of occurrences of spotted knapweed. As management progresses and open, grass- and sedge-dominated habitat increases, annual walk-through surveys to detect and remove spotted knapweed plants will become especially important in preventing a widespread infestation.

Removal of spotted knapweed can be accomplished by pulling or digging up plants, being careful to remove the entire root. Because the plant is a biennial, its only means of establishment is through seed dispersal. Therefore, it is critical that seeds are not spread while removing the plant. This is most easily accomplished by removing plants before they set seed. Once pulled, all plants should be bagged and removed from the site. When handling spotted knapweed it is important to wear gloves as compounds from the plant are suspected of causing cancer.

The herbicide picloram (Tordon ®) has also been shown to be an effective means of controlling the species. Picloram should be applied at 0.25 to .5 pounds per acre to rosettes in the fall or in spring after buds have formed but prior to flowering (Hoffman and Kearns 1997).

A prescribed fire with high heat intensity can help reduce established populations but will not eliminate the species (Hoffman and Kearns 1997). (For more information see the attached Element Stewardship Abstract in Appendix 5.)

MANAGEMENT CONSIDERATIONS

Fire and Species Diversity

Prescribed fire is the management tool best suited to restoring natural ecosystem functions to the pine barrens. Factors governing a burn's effect on the vegetation and structure of a management unit include heat intensity, frequency of occurrence, and seasonal timing. Burning during periods of low relative humidity will result in a more intense burn significantly reducing jack pine density and creating numerous snags. In areas where reducing the density of jack pine is not an overriding management concern, it may be desirable to minimize the heat intensity of a burn by conducting prescribed fires during times of high relative humidity. Creating different levels of heat intensity by burning under a wide variety of moisture conditions will allow species favored by each condition to coexist.

The frequency of burns will play a critical role in altering jack pine abundance as well as grass and forb cover. Research from tallgrass prairies and oak savannas has demonstrated that in those ecosystems annual burns result in increased grass cover and decreased forb and woody species diversity (Tester 1989, Collins et al. 1995). Conversely, long fire return intervals result in increased woody species diversity and decreased grass cover. An intermediate fire return interval was shown to result in the greatest species diversity. Alternating between short and long fire return intervals may be the most suitable strategy for reducing the cover of jack pine while bolstering both forb and grass diversity.

The season in which a burn is conducted may also shift the competitive balance between species. For example, several studies have shown cool season grasses such as the exotic Kentucky blue grass (*Poa pratensis*) to be adversely

affected by late spring burns, while the cover of warm season grasses such as little bluestem increased (Abrams and Hulbert 1987, Collins and Gibson 1990). Because the pine barrens system contains both native warm season and cool season grasses, burns conducted during a variety of different seasons will favor species diversity. Alternating burns between spring, late summer and early or late fall will provide opportunities for species adversely affected by a single burn regime to remain within the ecosystem. Conducting burns under different moisture conditions, alternating between short and long fire return intervals, and burning within different seasons will result in the highest species diversity for the management area.

Burning Constraints: Insects and Grassland Birds

To reduce the impacts of management on fire-intolerant species it will be important to consider a rotating schedule of prescribed burning in which adjacent units and sub-units are burned in alternate years (Table 4). This is especially important when planning burns in open grassland. Insect species that are restricted to these habitats have already experienced severe losses in the amount of available habitat due to forest succession brought on by years of fire suppression (Neilsen 1994). By burning adjacent management units or sub-units in alternate years, insect species from unburned units may be able to recolonize burned areas (Panzer et al. 1995). Avian species diversity is also thought to be enhanced by managing large areas as a mosaic of burned and unburned patches (Herkert 1991).

Loss of grassland nesting habitat has severely impacted many species of grassland birds. To minimize impacts to these species, frequent burns (e.g., annual or biennial) should be avoided during the nesting season (early May to late July) within open grasslands such as the sand prairie in Unit 7. In addition, land managers may need to restrict burning open grasslands during the nesting season when rare species are present.

Burning vs. Logging Dense Patches

Each of the management units contains areas of dense jack pine forest. These forest patches will need to be considerably reduced in size before the area begins to resemble a pine barrens. Reducing the size of the dense jack pine forest patches can be accomplished through the use of logging or by prescribed fire. Each management option has its benefits. Logging will generate revenue, allow direct control of forest patch size and tree density, and eliminate the potential negative consequences of a crown fire. Using prescription burning to reduce jack pine forests patch size is likely to result in a crown fire. There are several benefits of this management option. A crown fire is a very effective and low cost means of significantly reducing the patch size and density of jack pine. The dead snags that result from a crown fire will provide important nesting and foraging habitat for wildlife. Lastly, it presents an opportunity for research aimed at managing crown fires and studying their effects on various ecosystem components such as soil fertility, tree regeneration and ground flora response.

Increasing Grassland Habitat

Reducing jack pine patch size and cover will result in a direct increase in the size and frequency of open grassland. This will provide increased habitat to grassland plant and animal species. Rare plants such as rough fescue and Hill's thistle are expected to thrive under these more open conditions. Similarly, grassland dependent insects such as the red-legged spittlebug will also have more available habitat. The increase in grassland habitat will also provide critical habitat for grassland birds, many of which are currently in decline.

Avian species richness and abundance is expected to increase as the size and frequency of open habitat increases. Because much of the area is covered with jack pine forest and lacks structural diversity the bird community is presently dominated by habitat generalists. As grassland habitat is increased, a shift in avian community composition from generalist conifer-dependent species to a grassland suite of birds is likely to occur. As management progresses many

grassland and early successional species presently experiencing population declines are likely to benefit (see Table 5).

Table 5. Avian species likely to benefit from increased grassland habitat.

Species	Population Trend[1]	State Status
Horned lark	Decreasing	
Vesper sparrow	Decreasing	
Savannah sparrow	Decreasing	
Grasshopper sparrow*	Decreasing	Special concern
Field sparrow*	Decreasing	
Eastern kingbird	Decreasing	
Bobolink*	Decreasing	
Dickcissel*	Decreasing	Special concern
Upland sandpiper*	Decreasing	
Sharp-tailed grouse	Decreasing	Special concern
Common nighthawk	Decreasing	
Short-eared owl*	Decreasing	Endangered
American kestrel	Increasing	
Sharp-shinned hawk	Increasing	
Northern harrier*	Decreasing	Special concern

*Indicates species of management concern for U.S. Fish & Wildlife Region 3.
[1]Population trend in Michigan from U.S. Fish & Wildlife Breeding Bird Survey.

Adding Structural Diversity to the Tree Layer

Avian species richness is also likely to be enhanced by increasing the structural diversity of the tree community (Green 1995). At present, few red pine and no white pine occur within the management area, though they were common at the time of the GLO surveys. Because of their height, these species provide a number of microhabitat variables not presently found within the management area. Planting red and white pines will add an important missing component to the Grayling pine barrens ecosystem and will likely benefit a variety of songbirds, woodpeckers and raptors.

Community structure will be further enhanced by creating standing dead trees through burning and by allowing the present snags to rot in place. Standing dead trees are important to many wildlife species and provide birds with a variety of critical habitat components such as:

- cavities for roosting and nesting.
- hunting perches for raptors.
- song perches for passerines.
- foraging habitat for bark probers and gleaners.

Potential for Rare Plant Introductions

Because this area will be managed for ecosystem integrity and not specifically for resource production, the introductions of other native, pine-barrens species should be considered. For example, plant species such as pale agoseris and Alleghany plum could be introduced. These species occur in other pine barren remnants within the Grayling Outwash Plain Sub-subsection but have not been found within the North Camp Grayling Pine Barrens Management Area. Establishing new populations of these species within the management area may improve their chances of remaining viable over the long-term as well as provide land managers with an opportunity to learn more about their stewardship. Rare species introductions should use methods that promote the genetic diversity of the newly established populations such as collecting seeds from several different populations (3-5) over several years (2-3) and seasons and planting in a variety of micro-climatically different sites and conditions (e.g., see Reinartz 1995). Varying the collection and planting procedures will help ensure that a variety of different genotypes are represented, thus promoting the genetic diversity of the new population (Reinartz 1995).

Kirtland's Warbler Planning

As management progresses and new jack pine thickets are formed (e.g., 7-12 years), it is possible that the Kirtland's warbler may return to the area and begin nesting. Because of its current status (federal and state endangered) the species is legally protected from disturbance on its breeding grounds. To minimize or avoid disruptions to military training and management, it will be important to begin working with the Kirtland's Warbler Federal Recovery Team to plan for the possible return of the species to the site. Without these discussions the Kirtland's

warbler's presence will likely restrict the use and timing of various management and military training options.

MANAGEMENT CONSIDERATIONS OF UNITS AND SUB-UNITS

Unit 1

Unit 1 contains 4 sub-units (1A, 1B, 1C, and 1D) that are all bordered by gravel roads. Aerial photo interpretation shows that tree cover has increased considerably in the last 20 years. Large openings still exist in the northeastern and central parts of Sub-unit 1A and eastern-central 1C. Prescribed fires conducted in these sub-units should strive to maintain or increase the size of the openings. The burns should also include the hardwood portions of Sub-units 1A and 1C, as fire will help thin the stands and boost forb and grass production (Anderson and Schwegman 1991, Tester 1989).

Sub-unit 1B contains several large ice-block depressions. Their basins are filled with sedges and a thick mat of leaf litter allows for little forb diversity. Like pine barrens, these sedge meadow communities are also considered to be fire-dependent (Curtis 1959). It is likely that these sedge-dominated wetlands frequently burned when wildfires swept through the surrounding uplands. Prescribed burns conducted within the sub-unit should also include these wet meadows. Studies of prescribed fire in similar communities have shown that litter reduction through burning resulted in enhanced seed germination, seedling establishment, and forb diversity (Warners 1997, Kost 2000).

Sub-unit 1B also harbors several tall red pines. An effort should be made to protect these trees from cutting and burning (when feasible).

Spotted knapweed was found in Sub-unit 1B growing in a two-track that enters the unit, diagonally, from Stephan Bridge Rd. All spotted knapweed plants should be removed from the sub-unit and surrounding area. Surveys for spotted knapweed should be conducted annually in each of the sub-units and all plants should be removed.

Sub-unit 1D is a homogeneous stand of jack pine containing many small openings. Prescribed burns in this sub-unit should strive to enlarge the openings and reduce the overall cover of jack pine. Both rare plant species, Hill's thistle and rough fescue, occur within this sub-unit.

Unit 2

Unit 2 is divided into 4 sub-units (2A, 2B, 2C, and 2D), each bordered by gravel roads. A large patch (230 acres) of dense jack pine forest located in the northern portion of Unit 2 (e.g., sub-units 2A and 2B) may require the use of timber harvesting before prescription burning. However, the south half of the unit (e.g., Sub-units 2C and 2D) contains high quality pine barrens remnants. Prescribed fires here should strive to increase the size of the openings and decrease the overall cover of jack pine. Several rare species occur in sub-units 2A and 2B including the secretive locust, Hill's thistle, and healthy populations of rough fescue. Rare plant monitoring plots have been set up in these units (see Rare Plant Monitoring).

Sub-unit 2C contains a large ice-block depression that should be burned along with the rest of the sub-unit (see discussion above).

Sub-unit 2A contains a few tall red pines that should be protected from cutting and burning (when feasible).

Unit 3

Unit 3 contains 2 sub-units (3A and 3B). Sub-unit 3A contains scattered jack pines, open grassland, several ice-block depressions, and a lake (Duck Lake). It will be possible to conduct a prescribed fire in this unit without first logging. In addition to being bordered by roads, several gravel roads occur within the sub-unit and may provide additional fire breaks.

Sub-unit 3B is a heterogeneous mixture of remnant pine barrens, jack pine forest, dry mesic oak forest and aspen. The dense jack pine forest in the western portion of the unit may need to be cut before fire is introduced. However, a prescribed burn can be conducted in the adjacent oak forest and pine barrens remnant in the southeastern portion of the unit. Little ground layer diversity is found within the oak forest. The introduction of the fire will reduce the thick mat

of partially decomposed leaves that smothers the sandy soil and allow light to reach the forest floor. Thus, diversity may be increased as seed germination and seedling establishment are enhanced by litter removal (Anderson and Schwegman 1991, Laubhan 1995).

Two rare animal species were found in Sub-unit 3B. The red-legged spittlebug was found in a patch of little bluestem within the pine barrens remnant in the southeast and the secretive locust occurred in a jack pine stand in the northwestern portion of the sub-unit.

The eastern portion of Sub-unit 3B contains a large aspen stand and has been designated as a buffer strip. The decision to run a prescribed burn through this aspen stand should made by the forest manager and fire officer.

Unit 4

Unit 4 is fenced and contains the MPRC and Kyle Lake. The southeastern portion of the sub-unit has been cleared to build roads for military training. Spotted knapweed has infested this area and efforts here should focus on preventing its spread to other parts of the unit, especially the northeastern portion, where a high quality pine barrens remnant occurs. Although it may not be feasible to eradicate spotted knapweed from the southeast portion of the unit, preventing further infestations is essential and can be easily accomplished by conducting annual walk-through surveys in the more open portions of the sub-unit. All spotted knapweed plants growing outside of the infested area should be removed.

Both rare plant species, Hill's thistle and rough fescue, were found in the pine barrens remnants in the northeast portion of the unit. Gravel roads border this area on all sides and will facilitate prescription burning.

The central portion of the sub-unit is occupied by jack pine forest and contains many small openings, some of which support rough fescue. Because the area is bordered by deciduous forest to the west, and a road and pine barrens remnant to the east, prescription burning can be used here without first logging. Blackening (burning) the pine barrens remnant in the northeastern part of the sub-unit prior to burning the jack pine forest will add a large firebreak along the eastern edge of the area.

The western portion of the sub-unit contains deciduous forest (northern pin oak, red maple and aspen). If possible, prescribed burns should be run through this area to help stimulate grass and forb production and thin the understory (see discussion in Units 5 and 6).

Units 5 and 6

Unit 5 has been divided into 3 sub-units (5A, 5B and 5C) and Unit 6 is a single management unit. Each contain areas of jack pine forest, northern pin oak forest, recently logged areas, and small patches of aspen. The jack pine forests will need to be considerably reduced in size in order to restore the area to pine barrens. Because of the high density of jack pine, logging may be required before fire is introduced to these areas.

Where feasible, fire should also be introduced to the oak forests within these sub-units. At present there is little oak regeneration within these stands and the understories are dominated by red maple. Over time, prescribed fire will reduce the red maple density and help thin the understory. There is no need to harvest timber from the oak forests prior to conducting a prescribed burn as the fire intensity in these closed canopy systems is typically very low. In fact, because of the lack of ground layer vegetation it may be difficult to keep a fire burning except during times of low relative humidity. No direct oak mortality is expected from these prescribed burns. However, burning may scar the base of some trees and potentially decrease their resistance to disease. A strip of oak and aspen on the south side of Unit 6 may serve as a buffer. The decision to burn this strip should be left to the forest manager and fire officer.

The secretive locust and rough fescue were found in both units and Hill's thistle occurred in Unit 5.

Unit 7

The highest stewardship concern in the sand prairie is to control the spread of the exotic, spotted knapweed. This area is especially

vulnerable to spotted knapweed colonization because of the many patches of bare soil. At the time of the survey, spotted knapweed was found growing in missile holes. If not controlled, the species is likely spread to other parts of the management area. Following its eradication, surveys for spotted knapweed should be conducted annually and all plants removed.

Prescribed fire should be introduced to the sand prairie using a similar fire return interval as in the other units in order to boost forb and grass production and maintain the area as open grassland. Because the military uses this area for practicing aircraft drops of cargo and soldiers, it will be important to prevent shrub and tree invasion into the center of the unit. If woody plant encroachment becomes a problem, the fire return interval should be shortened (e.g., 3-10 years). No trees should be planted in Unit 7.

Rough fescue and Hill's thistle both occur in the unit. In addition, the blazing star borer moth is also likely to be found because its host plant is abundant.

MONITORING

COMMUNITY MONITORING

The community monitoring design has two components. First it seeks to provide land managers with a prescription burn decision-making tool by monitoring community structure. Secondly, it will help assess the impacts of management and military training on the pine barrens community by monitoring ground-layer species diversity.

Community Structure Monitoring

Jack pine abundance and distribution play a major role in determining the overall community structure of pine barrens ecosystems. Therefore, management actions impacting this species, such as prescribed fire and logging, may significantly alter community structure. By tracking changes in jack pine cover, land managers will be able to determine if they are meeting the management objectives of:

- reducing the overall cover of jack pine to 30% ($\pm$10%), and;
- limiting individual jack pine patch size to no more than 10% ($\pm$1%) of a unit or sub-unit.

A reliable assessment of jack pine cover is critical to determining whether management has met its objectives or if further management actions should be undertaken. Armed with information on how community structure has responded to past management, managers will be better equipped to achieve the project goals of:

- creating large open grass- and sedge-dominated areas, and;
- maintaining small isolated patches of dense jack pine.

Decision making flow charts to help managers assess management needs are provided in Figures 4 and 5.

Jack pine seedling distribution has the potential to significantly influence future community structure and should also be monitored. For example, if seedlings are clustered in some places and absent from others, the future community structure is likely to be a mosaic of openings and pine patches (e.g., pine barrens). If seedlings are scarce, or distributed throughout a site, a grassland or forest is likely to result. Furthermore, because jack pine responds to fire through seed dispersal, and fire facilitates seedling establishment, the distribution of jack pine seedlings may change radically following a single burn. Therefore, determining the distribution of seedlings within a management sub-unit 2-3 years after a prescribed burn will provide land managers with an estimate of future With this information, land managers can then better assess the management needs of the area. A decision-making flow chart illustrating this process is provided in Figure 5.

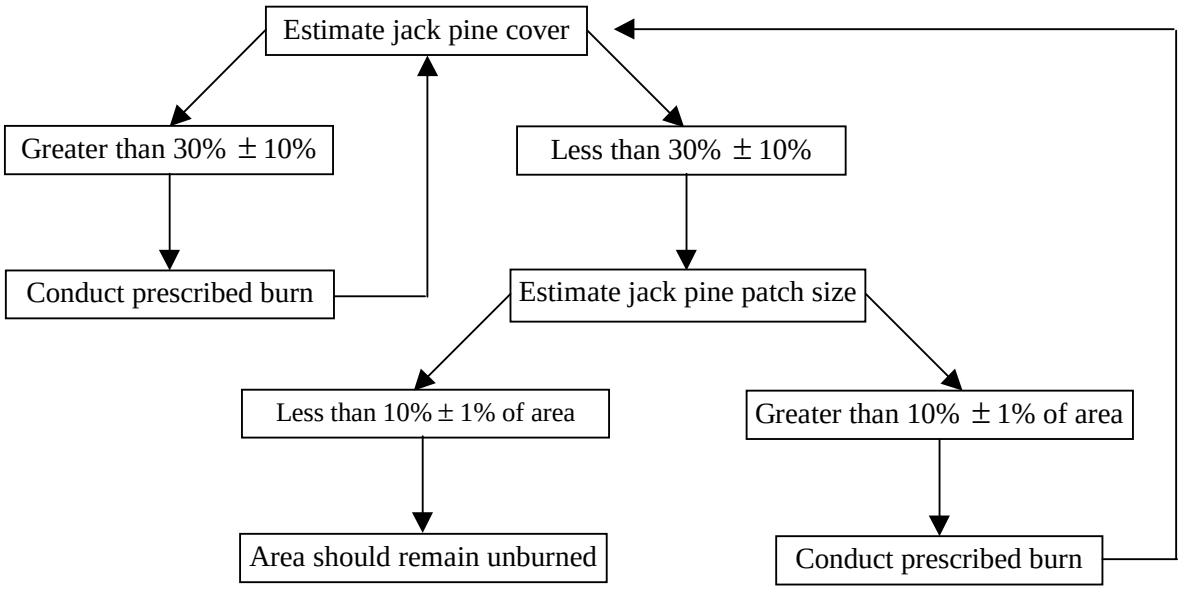

Figure 4. Prescription burn decision flow diagram for jack pine seedling distribution.

The three components that will require monitoring to determine present and potential, future community structure are:

- overall cover of jack pine for each sub-unit
- size of large jack pine patches in each sub-unit and
- frequency of jack pine seedlings 2-3 years after a burn.

Monitoring Methods: Jack Pine Cover and Patch Size

Monitoring procedures for assessing the overall percent cover of jack pine and percent and sub-unit follow. Both assessments require recent aerial photography and so can only be performed periodically. For example, 1998 aerial photos (DNR 1:15,840) have recently been made available and the next scheduled flight is expected in approximately 2008. Aerial photos are also available from the USGS both as prints and as Digital Orthophoto Quadrangles (1:12,000). The time between USGS flights may be as little as 5 years. Both scales (1:15,840 and 1:12,000) will work well with the procedures outlined below. These procedures should be performed whenever new aerial photos of the management area become available.

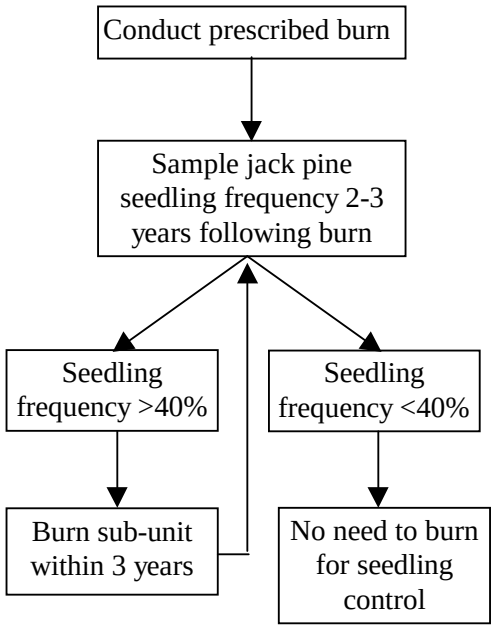

Figure 5. Prescription burn decision flow diagram for total jack pine cover and patch size

This method of estimating jack pine cover is reliable, low tech, and easy to use. However, as newer tools such as GIS, satellite imagery, and other advanced imaging technologies become more widely available they should be incorporated into the monitoring design.

To estimate total cover of jack pine and patch size in acres:

1. Place a dot grid (1 dot per acre and matching scale e.g., 1:15,840) over an aerial photo, positioning it so that it covers the unit or sub-unit of interest.
2. Count all the dots that fall within the area. For dots that occur along the edges of the unit or sub-unit, count every other one. The total number of dots counted is an estimate of the size of the area in acres (*A*).
3. Record the number of dots that overlay jack pine (*JP*).
4. Lastly, use the following equation to calculate the total percent cover of jack pine for a unit or sub-unit:

   % Total Jack Pine Cover = (JP/A) x 100
   where *JP* is the number of dots that overlay jack pine and *A* is the total number of dots that fall within the unit or sub-unit.

To determine if an individual jack pine patch is greater than 10% (±1%) of a sub-unit:

1. Following the procedure outlined above, determine the size (*A*) of the unit or sub-unit in which the patch of interest occurs.
2. Place the dot grid over the aerial photo and count the dots that fall within the patch (*a*).
3. For dots that occur along an edge of a patch count every other one. The number of dots counted is an estimate of the size of an individual patch in acres (*a*).
4. Lastly, use the following equation to calculate the percent of a sub-unit occupied by an individual patch:

   % Cover of Jack Pine Patch = (a/A) x 100
   where *a* is the size of in an individual patch and *A* is the size of the unit or sub-unit in which it occurs.

Monitoring Methods: Jack Pine Seedling Frequency

By determining the frequency of jack pine seedlings managers will have the ability to assess the potential, future distribution of jack pine within a sub-unit. If seedling frequency 2-3 years after a burn is estimated to be more than 40%, then the overall cover of jack pine has the potential to surpass the management objective (30% cover ± 10%). Frequency estimates greater than 40% should send a signal to land managers that a prescribed fire should be conducted within the next 3 years (see decision-making flow chart: Figure 5).

The following procedure for estimating jack pine seedling frequency utilizes plots placed along transects. The unit or sub-unit to be studied is divided lengthwise into 4 equal sections and a transect is run lengthwise through each of the sections. Using a random start, long thin plots (1 m x 10 m) are placed systematically along each transect and the presence of jack pine seedlings within the plots is recorded (see Figure 6 for a diagram of the sampling design).

1. Locate a unit or sub-unit that was burned 2-3 years previously.
2. Divide this area lengthwise into at least 4 equal sections (Figure 6).
3. Randomly locate a transect within each section. This can be done by designating a baseline along the narrow end of the sections and then choosing a number from a random numbers table (Appendix 6) and pacing this distance along the baseline. Run your transect from this point (Figure 6).
4. Place at least 25, equally spaced, 1 m x 10 m (10-m^2) plots along each transect so that the entire length of the unit or sub-unit is traversed.
5. The location of the first plot along each transect should be chosen randomly (e.g., by picking a number between 1-100 from a random numbers table and pacing this distance along the transect to the first plot).
6. Within each plot carefully search for jack pine seedlings and record their presence or absence. Because seedlings may be only 2-3 inches tall it is important that each plot be surveyed thoroughly. It is not necessary to record the number of seedlings, only their presence or absence.
7. To calculate the percent frequency of jack pine seedlings use the following equation:

   % Frequency of Seedlings = (n/N) x 100
   where *n* is the number of plots containing jack pine seedlings, and *N* is the total number of plots sampled.

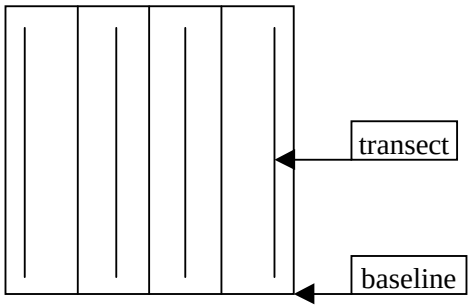

Figure 6. Jack pine seedling frequency monitoring diagram. The unit or sub-unit to be surveyed is divided into 4 equal sections and transects are run lengthwise through each. Transects are positioned randomly within each section from a common baseline.

Ground-layer Diversity Monitoring

Monitoring changes in ground-layer species diversity will provide managers with useful information for assessing the effects of fire and tree cover reduction on the management area. It may also be used to track changes in the ground layer that may occur as a result of increased off-road vehicle use. A monitoring design suitable for this task was originally developed as part of the Frost Pocket Pine Barrens Management Plan (Comer 1997). Annual ground-layer diversity monitoring has been underway in the Frost Pocket since 1997. The data from that project may provide a control area for assessing the differences between areas with, and without, off-road tracked vehicle use. In addition, ground-layer monitoring within the North Camp Grayling Management Area may also be designed to compare impacted and non-impacted sites. For example, an area within the MPRC such as the northeastern portion of Unit 4, where off-road tracked vehicle use is prohibited, may be compared to an area outside of the fenced MPRC such as Sub-Units 2B and 2C. These areas are presently very similar and should provide for a reliable comparison.

The monitoring design consists of recording species presence within randomly placed 1-m2 plots, placed along randomly located transects. For a detailed explanation of the method see the Frost Pocket Pine Barrens Management Plan (Comer 1997, pp. 9-10).

RARE PLANT MONITORING

The management goal for rare plants within the North Camp Grayling Management Area is to maintain or increase abundance of rough fescue and Hill's thistle. Specific monitoring objectives were developed for these species and also for pale agoseris and Alleghany plum, should they be encountered in the future. The rare plant monitoring is designed to assess whether the species are being effected by management. In addition, it may also be used to assess the impacts of off-road tracked and wheeled vehicles on rare plants should their use within the management area increase.

Monitoring was initiated in Sub-units 2C and 2D in August of 1999. Monitoring in Sub-units 2C and 2D should suffice for the entire management area unless burn frequencies, or off-road vehicle use differs significantly in other management units or sub-units. For example, if the fire return interval for any sub-unit is less than 3 years, monitoring should be initiated in that sub-unit and the results should be used to inform future burn decisions. Similarly, if off-road vehicle use is concentrated in one or more of the other units or sub-units, monitoring should be initiated there in order to gauge potential impacts. The monitoring design can be easily expanded by setting up additional macro-plots. In addition, because of the anticipated increase in off-road vehicle maneuvering outside of the MPRC, it is highly recommended that a rare plant macro-plot be established within Unit 4 to provide a control for comparing different levels of off-road vehicle use. Monitoring should be continued for at least 5 years following the initial prescribed burns. The 1999 monitoring results are presented in a separate section below and data are provided in Appendix 7. Additional monitoring data sheets for future rare plant monitoring are provided in Appendix 8.

Further, this site provides an excellent opportunity for study of these species' response to fire. In addition, this site may be used as a research area should a more detailed assessment of impacts from off-road vehicle use be required for permitting purposes.

Rough Fescue

Monitoring Objective

We want to be 90% sure of detecting a 20% change in the frequency of rough fescue within the designated macro-plot and are willing to accept a 1 in 10 chance that we'll say a change took place when it really didn't.

Methods

Previous monitoring efforts for this species have shown the identification of individual plants and estimates of cover to be difficult to determine, and possibly unreliable if different individuals conduct the sampling from year to year. In addition, rough fescue is well known from the western prairies as a fire adapted species, therefore rendering the need for more intensive monitoring of its response to fire less urgent. For these reasons and because of the limited scope of this project, the more reliable and cost effective method of frequency sampling was utilized. However, we know of no data regarding impacts from off-road vehicle use on rare pine barrens species. If off-road vehicle use increases outside of the fenced MPRC, we recommend that a macro-plot be identified in Unit 4 to serve as a control, for year two and subsequent years of monitoring. Further, this site provides an excellent opportunity for study should more detailed research on the response of this species to fire be desired or a more detailed assessment of impacts from off-road vehicles be required for permitting purposes.

A 25 x 25m macro-plot was established in the center of a large concentration of rough fescue located in the NW portion of Sub-unit 2D. The location of the plot was referenced with a hand-held GPS unit by taking three point readings and applying the necessary differential correction. The plot was also flagged in from East and West Buck Trail, which runs along the southern edge of the management unit. The southwest corner of the plot was marked with PVC piping and spray painted with florescent green paint. The nearest tree (jack pine) was also marked with paint, and the tree-to-corner point distance and direction recorded. Figure 1 shows the location of the monitoring plot within Sub-Unit 2D.

A 25 m baseline was run from the SW corner point directly north. Ten transects running east from the baseline were sampled. The starting points of the transects along the baseline were determined by selecting ten numbers between 0 and 25 from a random numbers table (Appendix 6). Presence or absence of rough fescue was noted in 1-m^2 quadrats at ten evenly spaced intervals along each transect. The starting point for the first quadrat sample along each transect was determined by choosing a random number between 0 and 9 for each transect. The initial sample quadrat was then placed with the lower left corner at the start point (dm) and projecting east so that the north edge lined up along the transect line (Figure 7). Subsequent quadrat

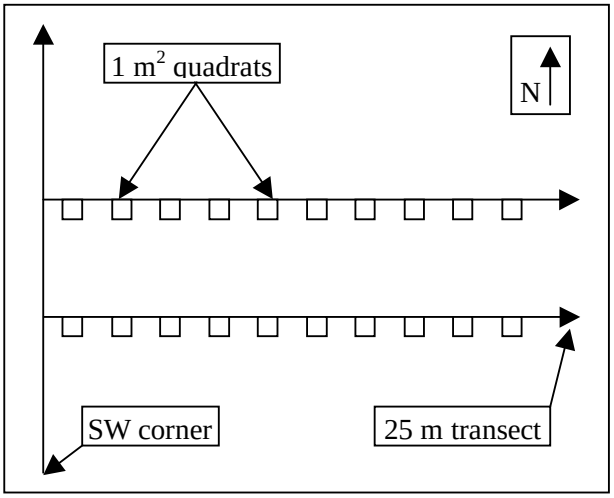

Figure 7. Diagram of transect and quadrant placement for monitoring rough fescue (10 transects should be sampled).

samples were then taken every 2.5 m from the start point, until 10 samples were taken per transect. For example, if the first random number was 3, the quadrat samples would be taken at .3 m, 2.8 m, 5.3 m, 7.8 m, 10.3 m, etc. Rough fescue was determined to be present if the species was rooted within the quadrat, but not present if rooted under the quadrat frame itself, or if other parts of the plant, such as leaves or inflorescence, were arching over the plot. The percent frequency was calculated by totaling the

number of quadrats where rough fescue was present and dividing by the total number of quadrats.

This sampling procedure should be repeated, ideally at the same time of year, for 5 years and compared to the initial year to determine if the population is increasing or decreasing. Trends between years can also be assessed by comparing the frequency from year to year. Since we do not know for sure what constitutes a biologically significant change in frequency for this species, we have included enough samples (100) to ensure the ability to detect a 20% change with 90% confidence. This number is often used as a first guess, when little is known about impacts to a given species, and can be re-assessed as more information on the biology and ecology of this species becomes available. If a 20% decrease in frequency is detected, a more detailed assessment of the population cluster should be made to determine if this is due to management activities. If it can reasonably be inferred that management activities or off-road vehicle use are implicated, these activities should be re-evaluated and mitigated. If the reason for the decline remains unclear, the development of a more detailed monitoring strategy should be considered in this sub-unit as well as in other management units and sub-units.

Hill's Thistle

Monitoring Objective

We want to be able to detect a change in the number of individuals in each life stage (e.g., seedling, juvenile, and adult) and the change in total number of plants for a population cluster.

Methods

Due to the rarity of this species in the management unit, it is difficult to design an effective quantitative sampling strategy that will provide useful estimates of population abundance, cover, or frequency. Therefore, the following monitoring efforts were implemented: 1) a qualitative assessment of abundance as determined by a timed-meander survey and 2) an actual count of a known population cluster.

Timed-Meander Survey

Management Sub-units 2C and 2D were meandered through over a two-hour period and the number of clusters and approximate number of individuals observed was recorded. The life stage and vigor of each individual, and any additional observations that may provide insight on the status of the population (e.g., herbivory) were also noted. The results of this monitoring, compared from year to year, will serve as a warning sign if the population appears to be declining or may provide clues regarding potential causes of decline and/or critical life stages. Conversely, it will provide a general indication of population increase resulting from management. If the qualitative estimate of population size decreases substantially, other monitoring strategies could be considered and/or more detailed research of population dynamics could be undertaken. If it can reasonably be inferred that management activities or off-road vehicle use are implicated in a decline of the population, these activities should be reassessed and mitigated.

Count of Known Population Cluster

A 30 m x 30m macro-plot encompassing all observed individuals was established around a population cluster in Sub-Unit 2C (Figure 1). The plot was oriented with sides projecting south to north and west to east. The four corners were marked by PVC piping and the distance and direction of the SW and NW corners to the nearest tree (jack pine) were recorded. The reference trees were spotted with green florescent paint. Four GPS reference points were taken with a hand-held GPS unit and the appropriate differential correction factor applied. In addition, the site was flagged in from the south along Bucks East and West Truck Trail.

A complete count of individuals in the cluster and length of the longest rosette leaf for each plant was recorded. This plot should be sampled for at least 5 years following the initial prescribed burn to determine if the total number of plants or number of individuals in each life stage increases or decreases. In addition, observations should be made to see if additional plants have established outside of the plot. This may indicate expansion or migration of the

cluster and provide insight into the mechanisms of dispersal or re-colonization used by this species.

Pale Agoseris and Alleghany Plum

Monitoring Objective

We wish to detect if these species were present but overlooked during past surveys. Further, we wish to infer whether seeds from the seed bank are stimulated to germinate by fire.

Methods

Pale agoseris and Alleghany plum were not found within the management area during the 1998 vegetation and rare plant survey or during the 1999 Hill's thistle meander survey. However, they could have been overlooked, or their seeds may be present in the seed bank. Because of this potential, monitoring for these species with a timed-meander survey in future years is recommended. This monitoring should be conducted at the same time and in the same manner as that for Hill's thistle (above). If either species shows up in significant numbers after burning, it would suggest that it is present in the seed bank and was stimulated to germinate by fire. It would be useful, at that point, to initiate a more detailed seed bank study and further monitor their response to management.

1999 RARE PLANT MONITORING RESULTS

Rough Fescue

Rough fescue was present in 41% of the plots. Data are included in Appendix 7.

Hill's Thistle

The population cluster within the Sub-unit 2C macro-plot contained 61 individuals, comprised of 17 seedlings, 41 juveniles, and 3 adults. Life stage was determined by the plant's reproductive status and length of its longest leaf. Non-flowering plants, or rosettes, were considered to be seedlings if their longest leaf was less than or equal to 4 cm in length, and juveniles if it was greater than 4 cm. All flowering plants were counted as adults. The numbers of fruiting heads on the 3 adult plants were 3, 6, and 6 respectively. The distribution of rosettes by length of the longest leaf is shown in Figure 8 and data are provided in Appendix 7.

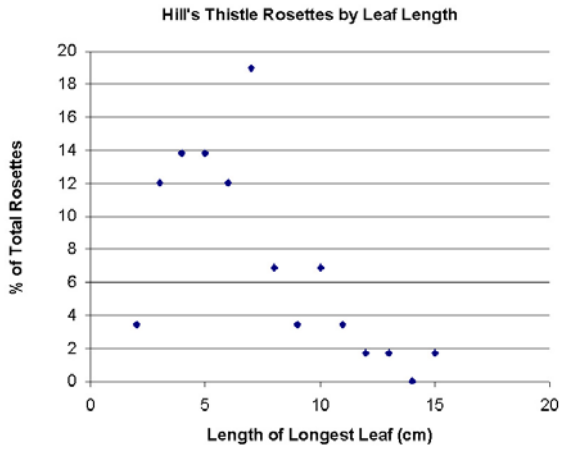

Figure 8. Percent of Hill's thistle (*Cirsium hillii*) rosettes from Sub-unit 2C macro-plot ordered by the length of their longest leaf (cm).

Pale Agoseris and Alleghany Plum

No individuals of the species were observed during the timed-meander survey.

ANIMAL MONITORING PROTOCOL

Birds

To monitor the avian community we recommend follow-up counts at the 15 previously established survey stations (see methods in Animal Inventories sections and Figure 1 for survey locations). Local volunteers (e.g., Audubon members) may be solicited to conduct the counts.

Insects

To determine if management has any effects on the populations of secretive locust, we recommend that timed-area counts be continued at all three known demes (one deme on edge of Sub-units 2C/5B, one in Sub-unit 3B, and one in Unit 6). Surveys should be conducted when the likelihood of encountering adults is high, typically from mid-August through mid-

September. A minimum of one hour should be spent at each deme using a combination of visual searches (tree trunks) and sweep netting (sweeping jack pine branches and the vegetation under the hanging branches of jack pine). Information should be kept on exact location, number, sex, and behavior. In addition, further *de novo* surveys should be undertaken in Units 1 and 4. With some training, a beginning surveyor could be taught to readily differentiate this species from similar looking grasshoppers and to distinguish sexes.

For the presence/absence monitoring of the red-legged spittlebug, sweep samples should be performed in August in each of the management units and sub-units wherever stands of little bluestem are located. A maximum of five stations per sub-unit should be searched. If resources are not available and no other surveys are conducted for this species, at the least, the known location in Sub-unit 3 should be swept after the prescribed fire treatment to determine if the species still occurs there. Sixty swings of the net (one per step) should be taken per sampling station. With a little training one can distinguish the red-legged spittlebug from most other insects. Information should be kept on exact sampling location and the number of specimens recorded per sweep sample.

CONCLUSION

This ecosystem management plan was developed for the "Pine Barrens Opportunity Area" originally identified by Higman et al. (1994) during a floristic and natural features inventory of Camp Grayling. It seeks to restore a globally and locally rare pine barrens ecosystem to a portion of North Camp Grayling. The plan calls for prescribed fire, as an ecosystem process, to be used in creating an open patchwork of jack pine thickets, grassland, and widely scattered red and white pines. The area was once part of a vast mosaic of grassland, pine barrens and jack pine-red pine forest. Presently much of the area is occupied by closed-canopy jack pine forest. Restoring the area to pine barrens is expected to bolster avian species diversity and abundance including both game and declining grassland birds. Rare species, including rough fescue, Hill's thistle, red-legged spittlebug, and secretive locust, are also likely to thrive in the more open pine barrens. In addition to using prescribed fire, the management plan also calls for limited plantings of red and white pines to help increase vegetation structural complexity, and an annual survey and removal of spotted knapweed. Monitoring protocols are also suggested to help guide the prescribed fire decision-making process and gauge the impacts of management and military training on ground-layer species diversity, rare species, and the bird community.

This ecosystem management plan for North Camp Grayling has been designed to allow for continued military and public use of the area while also restoring a functioning, native, pine barrens ecosystem. Rare plant and animal surveys conducted as part of this project identified several rare species within the management area. The management plan has been designed to protect these species and enhance the region's overall biodiversity while continuing to provide opportunities for military training and public recreation. This project represents a prime opportunity for ecosystem management in the northern Lower Peninsula. With the cooperation the DMA, DNR, MNFI and other interested parties we can restore a globally and locally rare ecosystem to the North Camp Grayling area.

ACKNOWLEDGEMENTS

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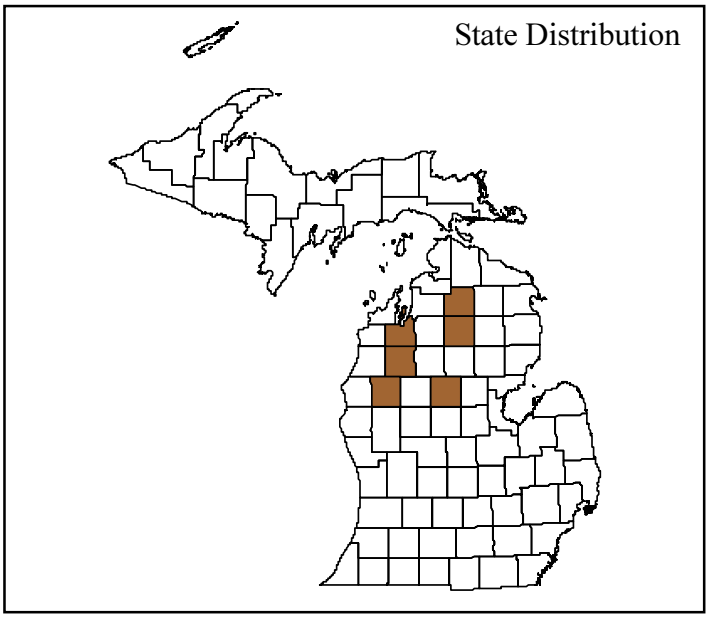
Appendix 1. Species Abstracts

Pine barrens



Global and state rank: G2/S2

Total range: Along with other fire-dominated plant communities, pine barrens in Michigan probably reached their maximum extent about 6,000 years ago when post-glacial climatic conditions were comparatively warm and dry. In the 1800s, this community was found throughout the High Plains of interior Lower Michigan, in several locations in upper Michigan, and in central Wisconsin. It also occurred on sand plains associated with the upper Mississippi and St. Croix Rivers in Minnesota and Wisconsin.

Rank justification: In the 1800s, nearly 270,000 acres of pine barrens were present in Michigan (Comer et al. 1995). About 210,000 acres were distributed in Lower Michigan from Kent and Muskegon counties northeast to Cheboygan and Alpena counties. Most of this acreage was concentrated in Crawford County (55,000 acres), Iosco County (33,000 acres), and Oscoda County (28,000 acres). In Upper Michigan, pine barrens were most concentrated on the Raco Plains of Chippewa County (32,000 acres). Today, fewer than five high quality examples are known in Michigan, totaling only a few hundred acres. However, it is likely that there are many areas of restorable pine barrens. Many former sites of this type were logged and/or succeeded to closed-canopy forests as a result of fire suppression. Fire suppression has also dramatically decreased floristic diversity in many areas, even if they remain open. Other sites continue to be converted to tree plantations. The natural component of *Pinus resinosa* (red pine) in pine barrens has often been severely reduced or eliminated by logging.

Landscape context: This community is generally found in cooler climates north of the tension zone in the Great Lakes region. Pine barrens are found on outwash plains, sand lake plain, and sandy riverine terraces. The topography is flat to gently rolling, typically with long expanses capable of carrying wildfires with few natural fire breaks. In rolling topography, pine barrens are found among depressions that collect cold air, forming frost pockets. The soils of this community are sandy, acidic, droughty, and relatively infertile. Zimmerman (1956) found all of Michigan's pine barrens occurring on excessively drained Grayling sands with a pH of 4.5-6.0.

Natural processes: Frequent wildfire and, in some places frost conditions, maintain open conditions by limiting the development of woody vegetation. Simard & Blank (1982) calculated presettlement fire frequency in the Mack Lake area of Crawford County to have averaged in the range of 13 to 41 years. Pine barrens likely occurred on the most frequently burned portions of that landscape. Frequent fire also limits the dominance of the mat-forming sedge *Carex pensylvanica* (Pennsylvania sedge), maintaining a higher diversity of grasses and forbs.

Vegetation description: *Pinus banksiana* (jack pine) typically dominates the scattered overstory canopy. At Crex Meadows in western Wisconsin, Vogl (1961) studied pine barrens as described by original land survey records. He estimated that there were 20 trees greater than 15 cm (6 inches) in diameter per hectare. This translates to an average distance between trees of 24 meters (65 ft). The trees in this community had typical open-grown shapes. They had branches most of the way down their trunks with many needles. Many burned jack pine snags were encountered by land surveyors in Michigan.

Several other tree species can be found in this community. Historically, there was commonly a scattered supercanopy of *Pinus resinosa*. Most of these trees were likely removed during the logging-era. *Pinus resinosa* and *Pinus strobus* (white pine) were occasionally common sub-dominants in

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Michigan pine barrens, especially in Lake County. Today, *Quercus ellipsoidalis* (northern pin oak), *Prunus serotina* (black cherry), and *Populus* spp. (aspens) are often found as stunted or young trees. *Vaccinium angustifolium* (low bush blueberry), *Comptonia peregrina* (sweet-fern), *Prunus pumila* (sand cherry), *Salix humilis* (prairie willow) and *Corylus* spp. (hazelnuts) make up most of the shrub layer when present. *Danthonia spicata* (poverty grass), *Schizachyrium scoparium* [*Andropogon scoparius*] (little bluestem), and *Carex pensylvanica* are dominant herbaceous species across the range of this community. Other herbs and forbs vary from one location to another, depending on local site conditions. *Andropogon gerardii* (big bluestem), *Deschampsia flexuosa* (hair grass), *Viola pedata* (birdfoot violet), *Aster oolentangiensis* (prairie heart-leaved aster), *Cirsium hillii* (Hill's thistle), *Koeleria macrantha* (June grass), *Liatris aspera* (rough blazing star), *Potentilla arguta* (prairie cinquefoil), and *Stipa spartea* (needle grass) are found on most sites.

This community has a well-developed sand prairie flora in the western end of its range. Sites in northern Michigan include fewer prairie-associated plant species.

Most of the recently collected data concerning tree height in this community indicate that most trees tend to be relatively short. Zimmerman (1956) reported that the tallest tree in his 50 study sites was 16 meters (52 ft). The average tree height was only 8 meters (26 ft). This may be misleading because past logging may have eliminated the largest trees and there has not been enough time to regenerate the tallest pines. Vogl (1961), in his analysis of General Land Office surveys conducted in western Wisconsin, found that the average diameter of *Pinus banksiana* was 25 cm (10 in) and *P. resinosa* was 50 cm (20 in). This indicates that taller trees may have existed before logging and the subsequent slash-fires that swept through most barrens.

Michigan indicator species: *Pinus banksiana*, *Schizachyrium scoparium*, *Viola pedata*, *Liatris aspera*, *Festuca scabrella*, *Cirsium hillii*, *Potentilla arguta*, *Prunus alleghaniensis* var. *davisii*.

Other noteworthy species: Many animals require this community to complete their life cycle. In Michigan, *Dendroica kirtlandii* (G1, Kirtland's warbler) breeds in dense jack pine thickets associated with this community. *Incisalia irus* (frosted elfin butterfly), is found on pine barrens. *Tympanuchus cupido* (prairie chicken) and *T. phaisanellus* (sharptail grouse) both need large tracts of open areas, as are found in pine barrens, to maintain viable populations. *Lycaeides melissa samuelis* (Karner blue butterfly) requires *Lupinus perennis* (common lupine). This forb is found in sites in Wisconsin and western Lower Michigan in low to moderate numbers. *Appalachia arcana* (secretive locust) occurs in and along shallow wetlands among pine barrens in northern Lower Michigan.

Rare plant species commonly associated with pine barrens in Michigan's Lower Peninsula include *Festuca scabrella*, *Agoseris glauca*, *Cirsium hillii*, and *Prunus alleghaniensis* var. *davisii*.

Poa pratensis (Kentucky bluegrass) is a common exotic grass in many sites of this community. It does best in the absence of fire. *Centaurea maculosa* (spotted knapweed), non-native *Hieracium* spp. (hawkweeds), and *Rumex acetosella* (sheep sorrel) have invaded many pine barren sites in Michigan.

Conservation/management: This community is maintained by relatively frequent ground fires. These fires suppress the growth of dense shrubs and sedges, while leaving most of the relatively fire resistant canopy trees intact. Oaks, especially *Quercus ellipsoidalis* are present as grubs and scattered trees when fire is frequent. Oaks can become a common part of the canopy in the absence of fire. Conservation planning to allow for future use of fire in the restoration and management of pine barrens is critical to their continued existence.

Research needs: Investigation into the frequency, periodicity, and intensity of fires in pine barrens is needed to guide restoration and management activities. Variation in composition and structure of vegetation across the Great Lakes region needs further clarification. Similar region-wide investigation is needed to describe the variation in typical spatial characteristics and landscape context of pine barrens. The invertebrate and non-vascular plant components of pine barrens are currently not well-documented.

Similar communities: These include dry sand prairie, oak-pine barrens, oak barrens, jack pine-oak forest, and Great Lakes barrens.

Historically, dry sand prairie was occasionally found among pine barrens. Small pockets of dry sand prairie in pine-dominated landscapes are sometimes classified as pine barrens. Great Lakes barrens are limited to the Great lakes shoreline and typically contain a significant number of evergreen understory plants. Pine barren remnants can also have a similar physiognomy and share some species with jack pine/sedge barrens that have formed as a result of logging activities. The anthropogenic communities, i.e. sites that have been logged, grazed, etc., tend to be less diverse and have more introduced species.

Other classifications

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 Resource Information Systems (MIRIS): 31, 33 - open land.

National Wetland Inventory (NWI): none.

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The Nature Conservancy National Classification: CODE: (III.A.4a.SW2.00).

Alliance: *Pinus banksiana-P. resinosa* (sparse woodland alliance)

Association: **Pinus banksiana**-*P. resinosa*/*Schizachyrium scoparium*-prairie forb (sparse woodland).

Related abstracts: Kirtland's warbler, secretive locust, rough fescue, pale agoseris, Hill's thistle, Allegheny plum

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Abstract citation

Corner, R.A. 1996. Natural community abstract for pine barrens. Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Funding for abstract provided by Michigan Department of Natural Resources - Forest Management Division and Wildlife Division, Non-Game Program.

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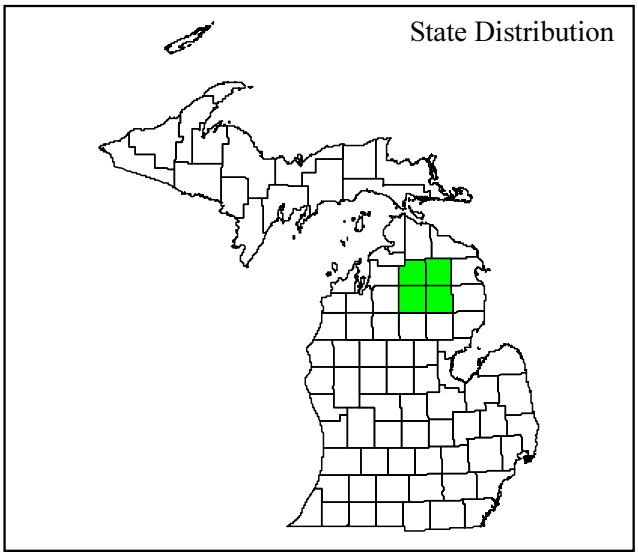
Agoseris glauca (Pursh) D. Dietr. pale agoseris



Best Survey Period

Status: State threatened

Global and state rank: G4G5/S2

Other common names: false dandelion

Family: Asteraceae (aster family)

Taxonomy: Several infra-specific taxa have been designated in this wide-ranging and variable species. Our plants are considered var. *glauca*.

Total range: A transcontinental species primarily of the northern Great Plains, *A. glauca* ranges from Alaska eastward to northern Ontario, and south in the Rockies to Arizona. Its occurrence in Michigan represents a disjunction of about 600 miles from the main range.

State distribution: In Michigan, pale agoseris is confined to the adjoining portions of Montmorency, Otsego, Crawford, and Oscoda counties, a range very similar to that of the somewhat more broadly distributed rare grass, rough fescue (*Festuca scabrella*, state threatened). It is scattered throughout this area and often occurs semicontinuously in remnant complexes of pine barrens. Both Zimmerman (1956) and Mustard (1979) reported searching unsuccessfully for the species in apparently suitable habitat of surrounding regions.

Recognition: From a **basal rosette of linear, fleshy, bluish-green (glaucuous) leaves**, which are toothless and range up to about 30 cm in length, pale agoseris produces leafless flower stalks about 20-40 cm tall, terminating in **single, large, yellow flower heads, similar to those of the common dandelion** (*Taraxacum officinale*). Like the dandelion and other similar-looking species, such as the introduced yellow hawkweeds (*Hieracium* spp.) and goat's beard (*Tragopogon* spp.), it has milky sap and a spherical fruiting head of soft, fine bristles. The coarsely toothed leaves of the common dandelion readily distinguish it from pale agoseris. Hawkweeds can be distinguished by their multiple, distinctly smaller flower heads, whereas goat's beard has larger flower heads with long, narrow, leaf-like bracts and leafy flower stalks. Pale agoseris is unlikely to be confused with the diminutive native dandelion, *Krigia virginica*, a superficially similar but much smaller plant with coarsely-toothed leaves.

Best survey time/phenology: This species is most easily recognized when it flowers and fruits, typically in June and July, although flowering and fruiting may occur well into October in some populations. With experience the characteristic leaves are recognizable during other periods of the growth season.

Habitat: Pale agoseris is restricted in Michigan to dry, grass-dominated clearings (and frequently along roads) in jack pine barrens and savannas. Many sites where it grows show evidence of logging and fires, but none more recent than about 15 years. Soils are acidic, with a pH ranging from about 5 to 7, consisting of well-drained Grayling and Rubicon sands. Mustard (1979) found plants often concentrated in topographic depressions or "frost pockets", where the best populations of this species are known to occur. Common associates include *Carex pensylvanica* (Pennsylvania sedge), *C. lucorum* (sedge), *Festuca scabrella* (rough fescue), *Cirsium hillii* (Hill's thistle), *Andropogon gerardii* (big bluestem), *Schizachyrium scoparium*

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[*Andropogon scoparius*] (little bluestem), *Vaccinium angustifolium* (lowbush blueberry), *Comptonia peregrina* (sweet-fern), *Hieracium aurantiacum* (devil's paintbrush), *Deschampsia flexuosa* (hair grass), *Prunus pumila* (sand cherry), *Pinus banksiana* (jack pine), and several characteristic lichens (especially *Cladonia* and *Cladina* species) and mosses.

Biology: *Agoseris glauca* is a perennial species with a deep taproot. It occurs sparsely within its Michigan range, characteristically as scattered individual plants. The fruits, with their long silky hairs (the pappus of the achenes) are wind-dispersed. The relative lack of variability in this wide-ranging species suggests that self-fertilization (apomixis) may be common.

Conservation/management: A large colony of *A. glauca*, reportedly the "best developed" in the state (Mustard, 1979) was destroyed by the creation of burial pits for PBB-tainted livestock. However, since other thriving colonies exist, this has not significantly altered the species' status in Michigan. Jack pine harvest, followed by prescribed fire, may benefit this species by perpetuating the open, early successional habitat it requires. Dedicated inventories in the general region have resulted in the discovery of significant pine barren remnants with populations of pale agoseris, rough fescue, and Hill's thistle, including some sites found and now being actively managed and restored in the Huron National Forest.

Comments: The native occurrence of *A. glauca* in Michigan has been questioned, since it was not collected until 1952, when the jack pine area of north-central Michigan was first intensively botanized by Zimmerman (1956). He suggested that *Agoseris'* existence here may be "the result of accidental introduction of seed or plants from farther west." Although the origin of this species in Michigan is somewhat problematic, the occurrence of pale agoseris with other western species such as rough fescue suggests that these species are indigenous remnants of a flora that migrated into the Great Lakes region during an abrupt warming period (the Hypsithermal) following Wisconsinan glaciation from approximately 11,000-8,000 years before present.

Research needs: It is supected that disturbance events (e.g. wildfires) that encourage openings within the jack pine barrens system have a positive impact on this species and associated rarities such as rough fescue. These types of management should be investigated to study the possibilities of restoration.

Related abstracts: pine barrens, Alleghany plum, Hill's thistle, rough fescue, secretive locust

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Abstract citation

Michigan Natural Features Inventory. 1996. Special plant abstract for *Agoseris glauca* (pale agoseris). Lansing, MI. 2 pp.

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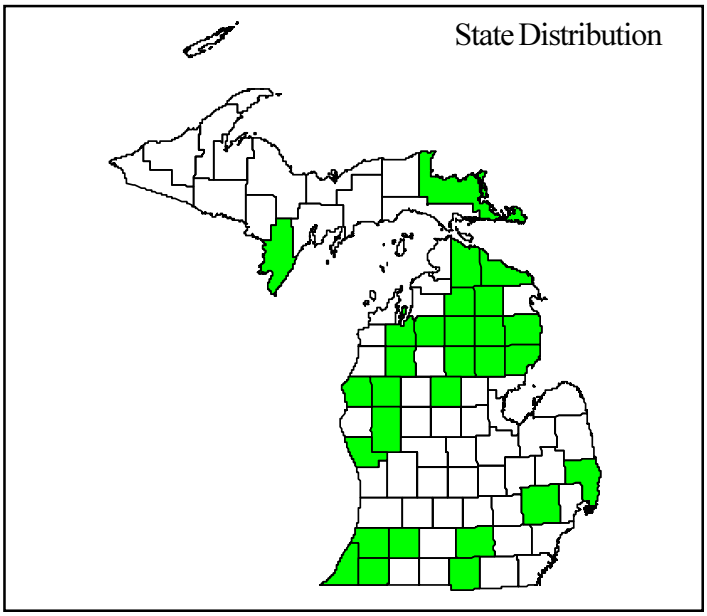
Cirsium hillii (Canby) Fern. — Hill's thistle



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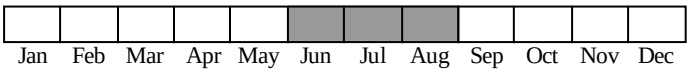

Status: State special concern

Global and state rank: G3/S3

Other common names: hollow-rooted thistle

Family: Asteraceae (aster family)

Synonyms: *Cirsium pumilum* (Nutt.) Sprengel

Total range: Hill's thistle is centered in the Great Lakes region, ranging from South Dakota and Minnesota to southern Ontario and Pennsylvania.

State distribution: Hill's thistle is concentrated in three areas the state; the Shakey Lakes oak savanna region of Menominee County in the Upper Peninsula, the jack pine barrens of northern Lower Michigan, and in alvar habitat on Drummond Island. Its stronghold is in the jack pine barrens of the northern Lower Peninsula in Crawford County. It has been documented in other widely scattered locations throughout the Lower Peninsula, particularly in former oak savanna habitat in the southern tiers of counties. Due to the highly disturbed nature of the majority of former oak savanna communities, the status of Hill's thistle in these locations is likely very poor if it is extant at all. It is also known from Beaver Island and other scattered locations.

Recognition: Hill's thistle is a generally short (25-60 cm tall), perennial thistle with a **deep, hollowed, and thickened taproot**. The **leafy stems** are soft, ridged and **sparsely pubescent or tomentose** (with woolly hairs), with 1-2 short branches near the top terminating with a **single, large, pink flower head 4-7 cm high**. The outer bracts at the base of the flower head are tipped by slender, short, and appressed spines. The elliptic-oblong leaves form a **basal rosette** with only a few progressively smaller leaves on the stem. The **leaf margins are typically undulating to very shallowly lobed** and sometimes slightly tomentose below, but often smooth on both surfaces.

Best survey time/phenology: Surveys are best conducted during the flowering period from June through August, however with experience this species can be recognized throughout the season both by the distinctive basal rosettes and fruiting heads.

Habitat: Throughout its range Hill's thistle is known from dry, sandy, gravelly soils in prairies, jack pine barrens, oak savanna, and open woods. In Michigan and Wisconsin, it is also known from limestone pavement communities known as "alvar". Species associates include typical prairie/savanna grasses such as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium* [*Andropogon*] *scoparius*), Indian grass (*Sorghastrum nutans*), poverty grass (*Danthonia spicata*), hair grass (*Deschampsia flexuosa*), June grass (*Koeleria macrantha*), and a variety of goldenrods, asters, and other prairie forbs.

In the pine barrens communities of Michigan jack pine (*Pinus banksiana*) and Pennsylvania sedge (*Carex pensylvanica*), in addition to the state threatened rough fescue (*Festuca scabrella*), state special concern Cooper's milk-vetch (*Astragalus neglectus*), and state threatened pale agoseris (*Agoseris glauca*) are also

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frequent associates.

Biology: This perennial species blooms from June through August and persists from about two to five years. Flowering occurs one or two seasons after the establishment of the rosette, most typically in three-year-old plants. Seed production generally is abundant; however, both flowers and seeds are vulnerable to insects and fungi. Seed are dispersed by wind, with often the entire fruiting head often being broken off and blown away. *Cirsium hillii* also reproduces vegetatively by adventitious buds that form along the lateral roots. The primary taproots die with the remainder of the plant after flowering. Several lateral shoots may be produced by a single plant. Suppression of the natural fire regime in historical *Cirsium* habitat has resulted in increased litter accumulation which is thought to be responsible for poor seedling establishment. This is likely one of the primary causes for the rarity of this species.

Conservation/management: Conservation and management of this species should be directed along two major approaches. One is to make a concerted effort to locate extant populations and prevent further direct destruction of their habitat which, in addition to disruption of the natural fire regime, is a major cause of the species decline. The second approach is to address the problem of poor seedling establishment due to increased accumulation of litter. This concern is primarily an issue within the dry jack pine, savanna, and prairie habitats where lack of fire has allowed considerable encroachment of successional plants. Management in theses areas with the use of prescribed fire is recommended. The accumulating duff layer is effectively removed by fire, opening up germination sites in the ground layer. Fire management may not be necessary in alvar communities where the harsh conditions appear to act as a natural check to woody species encroachment and resultant litter accumulation. In addition, in more mesic prairie/savanna communities, fire may actually have a negative effect. In these communities where lush prairie growth results from fire management, the thistle may actually be shaded out or out-competed by other species.

Research needs: The primary research needs for this species include more intensive inventory work to more adequately assess its status in Michigan, and further research on its basic life history, particularly the requirements for seed germination, seedling establishment, and vegetative reproduction, as well as the specific role of fire.

Related abstracts: alvar, pine barrens, dry sand prairie, oak savanna, Alleghany plum, pale agoseris, rough fescue, secretive locust

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Abstract citation

Higman, P.J. & M.R. Penskar. Special plant abstract for *Cirsium hillii* (Hill's thistle). Lansing, MI. 2 pp.

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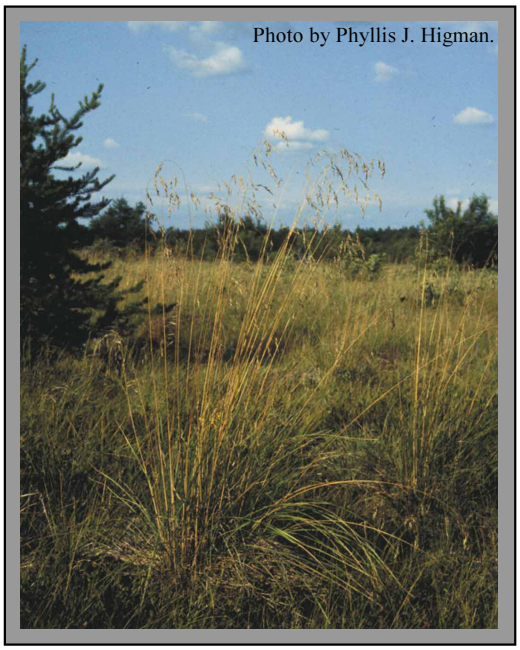
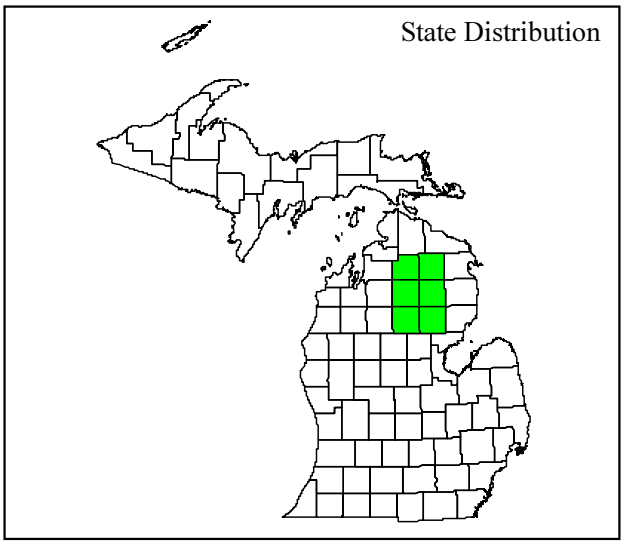
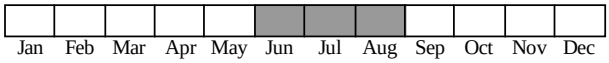
Festuca scabrella Torrey — rough fescue





Best Survey Period



Status: State threatened

Global and state rank: G5/S3

Family: Poaceae (grass family)

Synonyms: *F. altaica* Trin. ssp. *scabrella* (Torrey) Hultén; *F. altaica* Trin ssp. *altaica*; *F. altaica* ssp. *hallii* (Vasey) Harms; *F. hallii* (Vasey) Piper; *F. campestris* Rydberg var. *major* (Vasey) Gleason.

Taxonomy: Michigan plants were included in the western cordilleran variety *major* Vasey by Hitchcock (1951). *F. scabrella* is considered to be a subspecies of the transcontinental *F. altaica* by some authors (Harms 1984; Pavlick & Looman 1984) and Ontario plants have been assigned by various authors to *F. hallii* (Pavlick & Looman 1984; Aiken & Lefkovitch 1984), which is considered by Harms (1984) to be a subspecies of *F. altaica*.

Total range: *Festuca scabrella* 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. It is considered rare in Colorado (as *F. altaica* ssp. *scabrella*) and in Quebec and Ontario (as *F. hallii*).

State distribution: *F. scabrella* is narrowly restricted in the north central Lower Peninsula to adjacent areas of Crawford, Oscoda, Montmorency, Otsego, Roscommon, and Ogemaw Counties. It has not been collected in Roscommon County since the 1950s.

Recognition: Rough fescue usually forms **large, dense tussocks** with fertile stems reaching 3 to 8 dm in height. Its leaves, which are mostly basal, are narrow (1.5-4 mm) with **sometimes inrolled margins and the lowermost blades breaking off easily to leave stiff, persistent sheaths**. The few inflorescence branches are erect to somewhat curving, bearing narrow spikelets 8-10 mm long in which the second glume is nearly as long as the spikelet itself and the **lemmas are finely scabrous**. This species can usually be readily distinguished from other fescues by its robust, strongly tufted growth habit and its leaves that break off at the sheath. *Bromus kalmii* (prairie brome) may superficially resemble rough fescue in overall aspect, but the former has more drooping inflorescence branches and longer spikelets (15-25 mm), with the second glume much shorter in length than the spikelet. The similar looking *Schizachne pupurascens* (false melic) can be distinguished by its long awns and dense beard of hairs at the base of the florets.

Best survey time/phenology: Rough fescue is best identified when inflorescences are developed, such that it can be definitively distinguished from other tussuck-forming species. With experience, this species may also be sought during other periods of the growth season using detailed characteristics of the leaf as well as growth habit.

Habitat: *F. scabrella* grows in openings of sandy jack pine barrens with *Andropogon gerardii* (big bluestem), *Comptonia peregrina* (sweet-fern), *Deschampsia flexuosa* (hair grass), *Prunus pumila* (sand cherry), *Vaccinium angustifolium* and *V. myrtilloides* (blueberries), *Andropogon scoparius* (little bluestem), and *Agoseris glauca* (pale agoseris). It is often found growing at logged

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and burned sites which are now reverted to savanna. In the western portion of the range, rough fescue inhabits prairies, hillsides, open woods, pine plains, peaty or rocky meadows and barrens, and mountain slopes from foothills to montane areas. In many of these sites it is often the dominant, turf-forming grass species.

Biology: This perennial grass often develops short rhizomes, and individual plants tend to form characteristic round clumps or "stools". The spikelets mature in July. Rough fescue has a C-4 metabolism, and completes most of its growth in the cooler weather prior to midsummer.

Conservation/management: Many Michigan localities for rough fescue occur on state and federal lands. This species probably benefits from active management that promotes semi-open or savanna vegetation (such as that used to create Kirtland's warbler habitat). Since this is a cool-season grass and commences growth early in the season, late spring burns should be avoided. Studies of aspen parkland in Alberta, where rough fescue often dominates, indicate that repeated fire does not favor this species, reducing both its cover and inflorescence production (Anderson and Bailey 1980; Bailey and Anderson 1978). In addition, it is highly palatable to cattle, and may be grazed out in the main portion of its range (Looman 1983). The species may be best managed by protecting it from excessive grazing and employing prescribed burns, where fire is suppressed, to determine the most appropriate fire regimes.

Comments: Johnston (1958) suggests that Michigan's disjunct *F. scabrella* is a relict of the xerothermic post-glacial period, and migrated to our state via the Prairie Peninsula. Dore and McNeill (1980) regard Michigan's *Festuca scabrella* as introduced, after inspection of an Otsego County site in 1964. They do, however, entertain the possible validity of an Ontario record from north of Lake Superior in "jack pine land" with "a few other species of prairie affinity"—habitat at least generally similar to that of rough fescue in Michigan. The fact that this species was first collected in Michigan in 1951 has also cast some doubt on its status as a native member of our flora.

Research needs: The primary research need concerning this species in Michigan is to determine the effects of various management practices. In particular the use of prescribed fire to maintain vigorous, viable colonies and the open, early successional habitat this species requires to perpetuate itself, should be investigated.

Related abstracts: dry northern forest, jack pine barrens, Alleghany plum, Hill's thistle, pale agoseris, secretive locust

Selected references

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7-99/pjh

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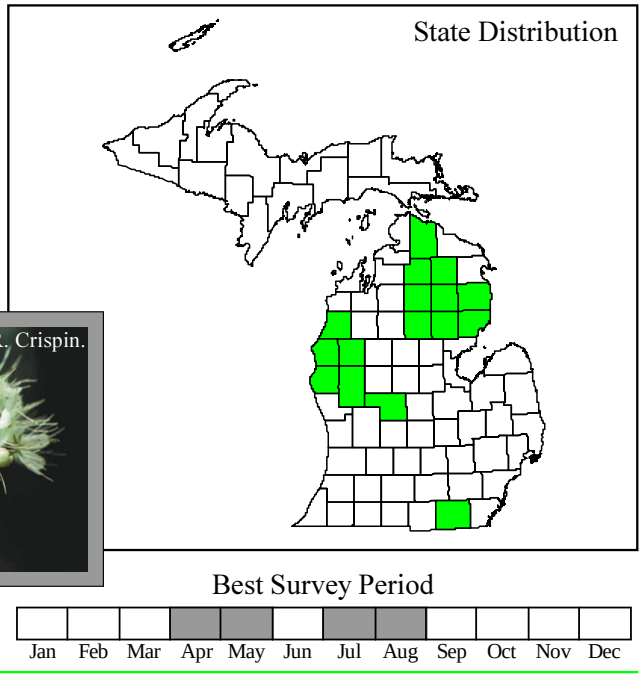
Prunus alleghaniensis var. *davisii* (Wight) Sarg. Alleghany plum



Status: State special concern, Federal species of concern

Global and state rank: G4T3Q/S2

Other common names: sloe plum

Family: Rosaceae (rose family)

Total range: *Prunus alleghaniensis* is distributed from central Pennsylvania through western Maryland to West Virginia, with outlying localities in Connecticut, Virginia, and eastern Tennessee. This species has also been reported as occurring in New York. Disjunct populations referred to as the endemic var. *davisii* (Wight) Sarg. are located in northern Lower Michigan and west-central Lower Michigan (Voss 1985; Wight 1915).

State distribution: This species is known from approximately 40 occurrences within the state, with a major concentration in the northern Lower Peninsula in Oscoda and Crawford counties. A second center of concentration occurs in the Manistee to Newaygo county region, where approximately 15 of the localities within the state are known. Three occurrences were recently documented in Lenawee County.

Recognition: Alleghany plum is a **straggly, thorny shrub**, or occasionally a small tree (to ~3 m), often characterized by the **persistence of dead, thorny blackish branches**. It occurs singly or forms large, dense clones that can result in fairly extensive thickets (Wight 1915). The **leaves are narrowly elliptic to oblanceolate**, 3-6 cm long with **acute or short acuminate tips**. They are smooth and shining above with **finely toothed, glandless margins**, and are scarcely developed when the flowers are fully expanded. The flowers are white petaled with **stamen filaments that turn dark pink with age**. The ovary and fruit are glabrous, while the **glandless sepals are slightly pubescent** near the base. Fruits are ~15 mm in diameter when fresh and ~10 mm when dry with hard stones that are ~5-8 mm broad. The similar *Prunus americana* Marsh (American wild plum) can be distinguished from Alleghany plum by its leaves that are conspicuously prolonged at the tip and by its larger flowers and fruits. The also similar *Prunus nigra* Aiton (Canada plum) can be distinguished by the presence of glands on the leaves and margins of the sepal lobes.

Best survey time/phenology: This species is most easily recognized at maturity during June when the darkened pink stamen filaments are a striking contrast to other similar species. Another good time for easier recognition is in April when it first begins flowering as it usually does so before the other early flowering *Prunus* and *Amelanchier* species with which it is most easily confused. Once into the peak of flowering, it can be distinguished by the pubescent sepal lobes that are glandless, in addition to the glandless teeth of the acute to acuminate-tipped leaves. During fruit it can be distinguished again by its leaves and by the smaller fruits.

Habitat: In the west-central portion of the Lower Peninsula, Alleghany plum occurs in old fields and remnant dry sand prairies. In the northern Lower Peninsula, it occurs in remnant openings in jack pine barrens. In both of these portions of the state, the soils are well drained, acid Grayling sands. It also tends to persist

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along roadsides. Typical associates include, *Prunus serotina* (black cherry), *P. virginiana* (chokecherry), *P. pensylvanica* (fire cherry), *Carex pensylvanica* (sedge), *Amelanchier spicata* (shadbush), *Vaccinium angustifolium* and *V. myrtilloides* (blueberries), C*omptonia peregrina* (sweetfern), *Salix humilis* (prairie willow), *Prunus pumila* (sand cherry), *Gaultheria procumbens* (wintergreen), *Maianthemum canadense* (Canada mayflower), and State special concern *Cirsium hillii* (Hill's thistle). In the pine barrens system, two other State listed species *Agoseris glauca* (pale agoseris, State threatened) and *Festuca scabrella* (rough fescue, State threatened) are also frequent associates.

Biology: Taylor (1990) indicates that this species is highly shade intolerant and prefers sites with morning sun and afternoon shade, particularly east-facing slopes. It has been found frequently on roadsides where the suppression of woody plants as a maintenance procedure has created openings that act as refugia for the plum. Since it is found in both dry sand prairie and jack pine plain communities which are systems that were historically dependent on natural fires to maintain their open character, it is likely that fire is an important disturbance factor for this species. It also has excellent soil holding ability which can assist in controlling erosion of the loose Grayling sands. It is known to flower early, typically in April and the seeds are dispersed generally during July and August by birds and mammals that eat the fleshy fruits.

Conservation/management: Alleghany plum is declining primarily because of loss of habitat through succession as a result of fire suppression. In addition, even though cleared roadsides appear to provide refugia for this species, other maintenance activities in these areas, such as herbiciding and construction, have been known to completely extirpate clonal populations. Management strategies must focus on the re-creation of suitable habitat for this species. The use of fire or mechanical overstory removal to create a mosaic of openings in the barrens or prairies is a potential management tool. An additional potentially good management technique is that of the re-introduction of this species into historical sites. A U.S. Forest Service tree nursery in the Huron National Forest in northern Michigan is currently exploring this option and has recently experienced some success in increasing it's seed germination rate.

Research needs: Of primary concern is the location of additional occurrences of Alleghany plum in Michigan. Systematic surveys should be conducted in remnant dry sand prairies and jack pine plains and in regions that historically contained these communities. Research regarding nursery propagation of this species and reintroduction into historical sites should be continued. In addition, research regarding important disturbance factors that maintain the open conditions necessary for this shade-intolerant species are critical.

Related abstracts: dry sand prairie, jack pine barrens, Hill's thistle, pale agoseris, rough fescue, secretive locust

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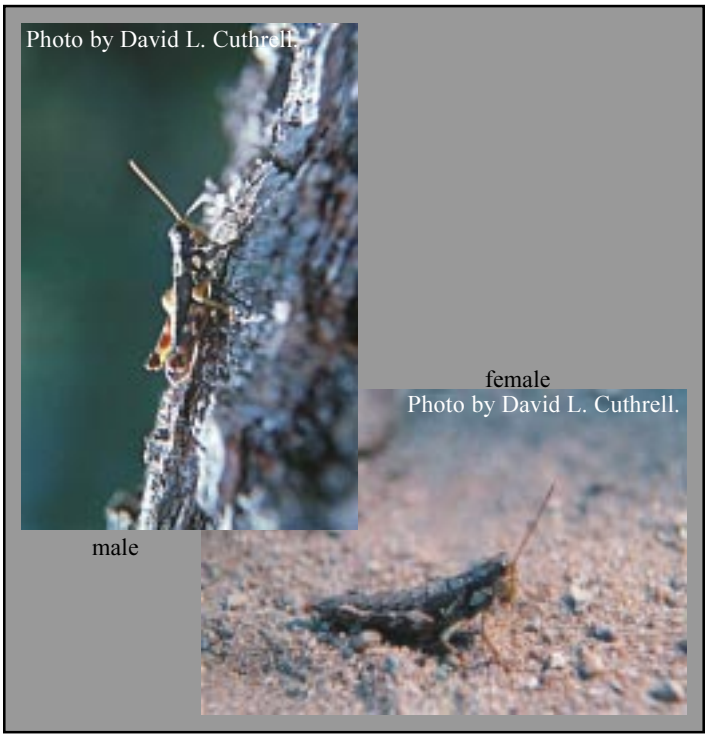
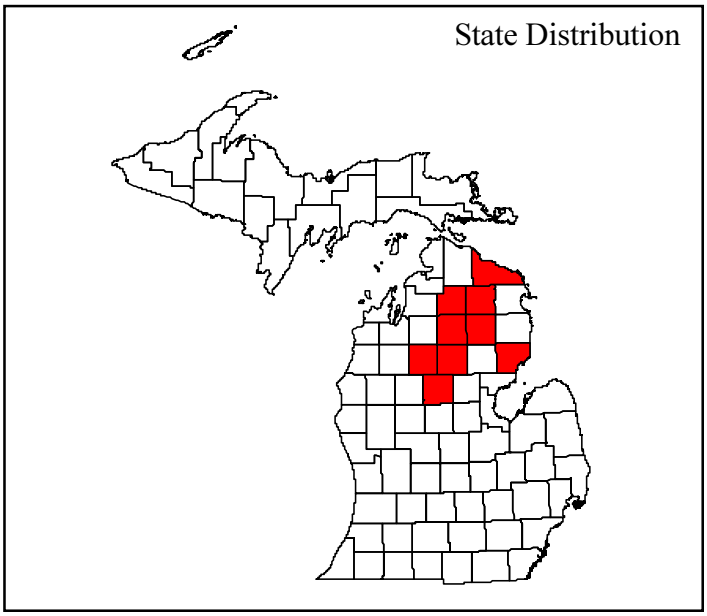
Appalachia arcana (Hubbell and Cantrall) secretive locust





Best Survey Period

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
							■	■			

Status: State special concern

Global and state rank: G2G3/S2S3

Other common names: Michigan bog grasshopper

Family: Acrididae (short-horned grasshopper family)

Range: *Appalachia arcana* is endemic to the northern half of Michigan's lower peninsula (Vickery & Kevan 1985).

State distribution: This species has been collected from 9 Michigan counties; records for 2 of these (Iosco, Missaukee) are known only from the late 1930s or early 1940s.

Recognition: The secretive locust is a relatively small, short-winged grasshopper which does not have the ability to sing or fly. Two field characteristics will confirm a specimen as *Appalachia arcana*. In both sexes, the **undersides of the hind femora are bright red** and the **tegmina (forewings) are reduced to small pads held almost laterally along the body**. *Booneacris glacialis canadensis* (northern wingless locust) can occur in the same habitats at the same time of year, but has yellowish-green on the underside of the hind femora and lacks wings entirely. Female *Booneacris* have a deep olive cast to their bodies with white or bright pink spots on the pronotum (neck) and elsewhere, while the males are significantly smaller, less olive, and more deeply lime green in color. It is critical to check for these characteristics, because these two species are quite similar in appearance (Higman et al. 1994). *Appalachia arcana* **males range in length from 17-19 mm (0.7-0.8 inches) and females from 24-30 mm (1.0-1.2 inches)**. **Males** are brownish gray in color and have a **conspicuous broad pale stripe dorsally**, with contrasting lateral black stripes extending from the head almost to the end of the abdomen. Females are more subtle shades of brown and lack the prominent striping of the males. The **hind femora** of both sexes are **prominently striped laterally with alternating light and dark brown bands**. Though the male's coloration is more noticeable, both sexes can be quite cryptic and difficult to see against the bark of trees and shrubs.

Best survey time: Adults have been observed from early July until November, though typically they are found between August and September. They are most easily seen in the mid-mornings and early evenings when activity peaks.

Habitat: The habitat of this insect may not be fully known. Hubbell and Cantrall (1938) suggest that it may occur in almost any habitat that is shrubby yet open enough for full sunlight exposure through large parts of the day. However, the species is best known from bogs where leatherleaf (*Chamaedaphne calyculata*) and Labrador tea (*Ledum groenlandicum*) typically occur in dense stands underlain by deep, hummocky sphagnum. These bogs often are surrounded by stands of jack pine (*Pinus banksiana*) and some tamarack (*Larix larcina*) which may encroach along the margins of the bog. The species also has been documented on bracken fern (*Pteridium aquilinum* var. *latiusculum*) and sweetfern (*Comptonia peregrina*) in open groves of aspen and pines (Vickery and Kevan 1985), in early shrub thicket stages of second-growth hardwood forests, in shrubby undergrowth in jack pine barrens (Hubbell and Cantrall 1938), and in northern

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wet prairies and intermittent wetlands (Higman et al. 1994).

Biology: The best source for life history and ecological data remains Hubbell and Cantrall's species description (1938). As the common name implies, the species is secretive and may only be detected where it is abundant. Hubbell and Cantrall (1938) observed that this insect spends most of the day sunning itself, shifting its position to follow the path of the sun and moving to the undersides of twigs and branches or on the trunks of trees for the night. Males are most commonly observed sunning themselves on the branches of leatherleaf or on the trunks and branches of jack pine and tamarack (Vickery & Kevan 1985). They tend to remain motionless, largely hidden by their cryptic coloration. When they do move, they appear 'jerky and nervous', leaping two to three times in a rapid zigzag fashion down the tree. If they reach the ground, they may burrow into moss or plant debris. Females typically remain hidden closer to the soil surface.

Mating has been observed in the field in mid to late September, usually on trunks of trees over 5-6' tall (H. Ballard 1989 pers. comm.). Hubbell and Cantrall (1938) noted that pairs have been observed to remain in copula for up to twelve hours. During oviposition, which has only been observed in captivity, eggs were laid on twigs rather than in the soil, and were suspended in a frothy material which hardened into brown globose masses from 8-12 mm in diameter. In the wild, it is thought that the eggs are laid in the soil of surrounding uplands rather than in sphagnum, and that the early instars (immature stages) later migrate to bogs from their margins (Hubbell & Cantrall 1938). Ballard (1995 pers. comm.) suggested that this orthopteran may be more of an arboreal species than a ground-dweller, since most of the individuals he observed were found in the shrubs and trees. He pointed out that oviposition may in fact take place on the branches of shrubs rather than in the soil of adjacent uplands. The secretive locust is univoltine (one generation each year), overwintering in the egg stage. The eggs presumably hatch in early summer.

Conservation/management: The secretive locust may occur in locations affected by gypsy moth defoliation, but the species (like all grasshoppers) is immune to the type of Bacillus thuringiensis (Bt) used to control the gypsy moth. They are, however, adversely impacted by Dimilin, a regulated pesticide for restricted use, that is sometimes used by private landowners and which affects growth in orthopterans. The locust also could be affected by development, road construction, and logging at occupied sites. Uncut buffer areas around bogs/wetlands may be necessary to protect oviposition sites. Because habitat needs are unclear, the maintenance of a mosaic of suitable upland and wetland habitats in their natural state is prudent until further research more clearly defines specific habitat requirements.

Research needs: Life history studies are needed to determine oviposition sites, dispersal mechanisms, and other special habitat needs. Field surveys would help determine distribution and abundance. The effects of timber harvest at different intensities, as well as conversion of upland forest to red pine, should be examined. The impacts of prescribed burning in nearby habitats should be assessed to determine the effects this may have on potential oviposition sites, possible food plants, and recolonization efforts. Intensive monitoring from June through October at a number of known sites could provide invaluable information about this species. Mark-recapture studies should be conducted to better estimate population size at several known sites. Studies should be designed to evaluate the degree of habitat fragmentation and isolation tolerated by the secretive locust.

Related abstracts: pine barrens, bog, intermittant wetland, pale agoseris, rough fescue, Kirtland's warbler

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Abstract citation

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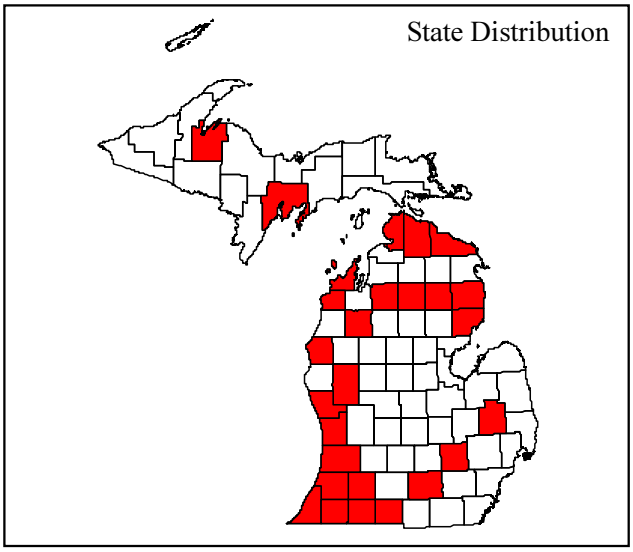
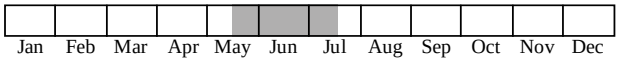
Dendroica discolor (Viellot) prairie warbler


Photo by R.R. Wadman.



Best Survey Period



Status: State endangered

Global and state ranks: G5/S1

Family: Emberizidae (warbler family)

Range: The prairie warbler primarily breeds in the southeastern United States. Two sub-species are recognized and include *Dendroica discolor discolor* and *Dendroica discolor paludicola* (Evers 1994). The more northern sub-species (*D. d. discolor*) ranges from eastern Oklahoma and northeast Texas; east to the Atlantic coast; and north to New England, southern Ontario, and Michigan. Highest abundances are concentrated in the southern Piedmont Region (Robbins et al. 1986). Midwestern populations are often local, disjunct, or absent from areas of seemingly suitable habitat (Evers 1994). Wintering grounds for *D. d. discolor* occur in southern Florida, the West Indies, Central America, and South America, with small numbers wintering in Mexico (American Ornithologist Union 1983). The southern sub-species, *D. d. paludicola*, is found in mangrove habitats along the southeast coast (primarily in Florida) (Robbins 1986) and typically it is non-migratory (American Ornithologist Union 1983).

State distribution: Michigan is on the northern periphery of the prairie warbler's range (Evers 1994). Breeding activity primarily occurs in the Lower Peninsula. Evidence of breeding in the Upper Peninsula has only been documented in Baraga County (i.e. juvenile birds observed) (Evers 1994 and Walkinshaw 1959) and Delta County (Brewer et al. 1991). Most populations and solitary singing males are confined to dune and shoreline habitats along the Lake Michigan coast (Brewer et al. 1991). Largest populations are located in Mason and Benzie counties, and this species is now scarce in the high plains area, where it was once abundant (Evers 1994). Nesting is confirmed in Benzie and Livingston counties; nesting is probable in Cheboygon, Kalkaska, Crawford, Alcona, Mason, Muskegon, Newaygon, Van Buren (Brewer et al. 1991), Allegan, Presque Isle, Alpena, and Berrien counties (Michigan Natural Features Inventory unpublished data 1999); nesting is possible in Delta, Emmet, Leelanau, Oscoda, Wexford, Lapeer, Ottawa, Kalamazoo, Jackson, Cass, and Branch counties (Brewer et al. 1991).

Recognition: The prairie warbler is a medium sized warbler that has yellowish-green upperparts and a bright yellow under-surface. Prominent **black streaks are confined to the flanks** and chestnut colored streaks are apparent (upon close examination) along the back. **Two black streaks are on the head** (one through the eye, and the other along the jaw). Sexual dimorphism is minor with females having less prominent streaking. Immatures look similar to females. The song of the prairie warbler is a **distinctive buzzy song that ascends in scale (e.g., zee, zee, zee, zee zeet)**. Typical songs consist of 8-14 notes. Prairie warblers are also the only yellowish warbler with a characteristic "tail bob" (Evers 1994).

Best survey time: The best time to survey for prairie warblers is from late May through mid-July. This time period is optimal because breeding males readily sing on their territories and are quite conspicuous. A standard survey methodology for this species is to systematically

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place observation points every ¼ mile throughout suitable habitat. At each observation point an observer listens for 10 minutes and records all birds observed and/or heard within 50 m and beyond 50 m of the survey point (Ralph et al. 1995). Another simple method is to simply walk a transect through suitable habitat during the breeding season (mid-May to mid-July) and record individuals observed and/or heard (Bibby et al. 1992). All surveys should be conducted between sunrise and 10:30 am during good to fair weather conditions (e.g., low winds, dry).

Habitat: The prairie warbler prefers upland scrub-shrub habitats. Optimal breeding habitats are usually associated with poor soils and include brushy dune/lakeshore communities, fallow fields with scattered trees, young jack pine stands, pine plantations (especially Christmas tree plantings), oak clearcuts, and powerline right-of-ways (Ever 1994). Large openings surrounding or containing clumps of shrubs are typical components of breeding habitat. Populations typically exploit sites for short periods of time because preferred breeding habitat (early seral) coincides with rapid structural change in plant structure and composition (Evers 1994).

Biology: This species is a neo-tropical migrant that breeds in Michigan. Breeding in Michigan typically takes place from late May through mid-July. Prairie warblers place their nests in a shrub or sapling, usually 1-10 ft above the ground. The nest is a compact cup of plant fibers, small dead leaves, grasses, bud scales, fern and seed down, and lined with hair and/or feathers. Eggs are typically laid in June and young hatch within 11 – 15 days after eggs have been laid. Typically, 3-5 eggs are produced and are solely incubated by the female. The young are altricial at the time of hatching and are tended by both parents. Most young fledge between 8 –10 days old and remain dependant on the parents for an additional 30 – 35 days after hatching (Baicich and Harrison 1997). The diet of the prairie warbler consists of a variety of small invertebrates. Adults glean insects and spiders from vegetation and young are primarily fed caterpillars (Evers 1994)

Conservation/management: Populations of the prairie warbler have declined nation-wide (Askins 1993) as well as in Michigan (Evers 1994). Globally this species seems secure but populations in the Mid-west are of moderate to high management concern (Robinson et al. 1999). Historically, prairie warblers in Michigan were common in the north-central (i.e., jack pine plains) and southwestern lower peninsula. Currently, Michigan populations are small and disjunct, which results in isolated populations that are forced to be self-sustaining or dependent on the sporadic immigration of individuals into the population. As a result of the diffuse nature of Michigan prairie warbler populations, it is difficult to assess the relative rarity of this species (Evers 1994). Michigan currently supports large areas of apparently suitable habitat (i.e., jack pine plains), however many of these areas remain unoccupied. The reasons for this are not well understood and some researchers have suggested that the habitat requirements of the prairie warbler may be much more specific than anticipated. Conditions on the wintering grounds also might explain declines in Michigan and throughout the Mid-west (Evers 1994). Major threats to the prairie warbler in Michigan are habitat loss and cowbird parasitism, which significantly lowers nesting success. Further, nesting success is significantly hampered due an extremely high rate of nest predation (which effects nearly 80% of all nesting attempts). Typical nest predators include snakes, chipmunks, and blue jays (Nolan 1978).

Management practices that are beneficial to the prairie warbler include prescribed burning, allowing natural succession to proceed in fields, creating large cut-over areas, maintenance of large thickets in agricultural areas, and establishment of pine plantations (Askins 1993). Dune/shoreline habitats should be protected since they often provide excellent habitat for prairie warblers and apparently support viable populations in Michigan (Evers 1994). Before creating early seral habitats for the prairie warbler in a largely forested area, managers should assess the impacts on other species, such as forest interior birds. Extensive tracts of forest should not be fragmented with numerous open areas, since many species are patch size sensitive and cowbird parasitism increases as habitats become more fragmented. Rather, large contiguous blocks of open habitats and forest should be aggregated into separate areas to abate the adverse effects of fragmentation on open-land and forest interior species (Askins 1993, Petit et al. 1995). Prairie warbler management is most likely compatible with Kirtland's warbler management, pine barrens restoration, and regeneration of upland intolerant tree species such as oak, pines, and aspen.

Research needs: A better understanding of the state's distribution and relative abundance/rarity is needed. Further, research conducted on the habitat requirements such as minimum patch size, vegetation structure, and landscape patterns are needed to better manage this species.

Related abstracts: pine barrens, open dunes, wooded dune and swale, Hill's thistle, pale agoseris, rough fescue, Lake Huron tansy, Pitcher's thistle, Houghton's goldenrod, Kirtland's warbler, piping plover

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Abstract citation

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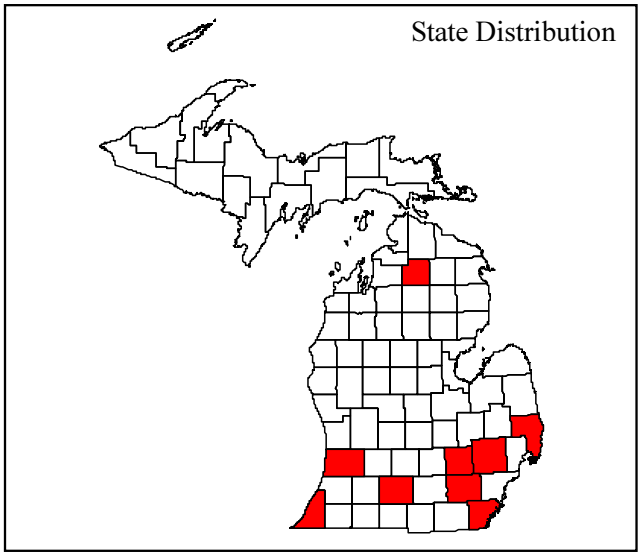
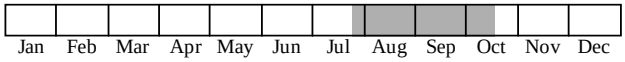
Papaipema beeriana Bird — blazing star borer


Photo by David L. Cuthrell.



Best Survey Period



Status: State special concern

Global and state rank: G3/S1S2

Family: Noctuidae (owlet moth family)

Range: The blazing star borer occurs as a series of disjunct populations throughout the midwestern United States having been recorded from the following states: Iowa, Illinois, Indiana, Ohio, Wisconsin, and Michigan.

State distribution: The blazing star borer is known from less than 12 sites in Michigan and has been reported from ten counties. It has been collected from several southern counties (Allegan, Berrien, Calhoun, Washtenaw, Monroe, Livingston, Oakland, and St. Clair) and one county in the northern lower peninsula (Otsego).

Recognition: This moth, in the family Noctuidae, has a wing-span of 31-36 mm (1.2-1.5 in). It has two color forms, both spotted and unspotted. **The unspotted form has forewings which are dull brownish, frosted with whitish scale-bases, and with scattered white scales**; markings practically absent or very faint (Forbes 1954). The hing wings are a paler and more uniform gray. **The spotted form, *lacinariae* Bird, has forewings similar to the unspotted form with the exception of white spots** (Forbes 1954). Many species of *Papaipema* are difficult to identify but most can be sorted into species groups (Rings et al. 1992). These species groups can then be sent to experts for positive identification. Series (5 to 10 individuals from the same location) of specimens are easier to work with because of the large amount of individual variation. In addition, many field-collected specimens can be quite worn (many of the scales missing) giving the specimen a lighter appearance than normal, or eliminating many of the scale characteristics important for identification. To add to the confusion some species, like the blazing star borer, have spotted and unspotted forms, both of which are sympatric (occur at the same location at the same time).

Best survey time: The blazing star borer is a late-season flier with Michigan adult capture dates ranging from 13 September through 5 October. The best way to survey for this species is by blacklighting, a technique where a sheet is stretched across two trees or poles and an ultraviolet light is used to attract moths to the sheet. Moths can be collected directly from the sheet. You also can search for the larvae of many species of *Papaipema* by searching for signs of feeding activity in late July or early August. This includes inspecting blazing star (*Liatris* spp.) plants that are wilted or otherwise stunted, for a small hole near the base of the plant and a pile of frass (caterpillar feces) near this opening. Often times you can see the pile of frass at the base of the plant and then locate the hole in the stem.

Habitat: The blazing star borer occurs with its larval host plant, blazing star or snakeroot (*Liatris* spp.) In Michigan the species has been recorded from a variety of plant communities crossing gradients from wet to dry including lakeplain prairies, prairie fens, and sand prairie or barrens. Many Michigan sites represent only small parcels of what was once widespread habitat. At known sites associated prairie plants typically include big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), common mountain mint (*Pycanthemum virginianum*), tall coreopsis

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(*Coreopsis tripteris*), Ohio goldenrod (*Solidago ohioensis*), Culver's root (*Veronicastrum virginicum*), and switch grass (*Panicum virgatum*).

Biology: Eggs are laid on or near the food plant in the fall and hatch in the spring around mid-May (Bird 1923). Larvae can be found in the root and lower stem of the host plant in most years from 14 July-7 August. Feeding and tunneling in the root causes the plants to wilt and the leaves can turn brown at the tips. The final instar leaves the root and pupates in the soil near the plant. Pupae can be found from 10 August until the adult flight times of 13 September through 5 October. *Papaipema* moths as a whole fly late in the season, usually late August through October. There is also limited data that suggest prairie *Papaipema* moths are active late in the evening (actually early morning hours) (Schweitzer 1999). Based on our blacklighting observations in southern Michigan, *beeriana* is active for a short period of time beginning around 2300 and ending near 2400 hours EST. Several factors need to be considered including ambient temperatures, humidity levels, precipitation, wind, and moon phase; all of which affect moth behavior. Major natural enemies of *Papaipema* include mammals such as rodents and skunks (Hessel 1954, Decker 1931, Schweitzer 1999), woodpeckers (Decker 1930) as well as numerous parasitoids and predatory insects. Small mammals in some cases can completely eradicate small populations (Hessel 1954). A tachinid fly, *Masicera senilis*, and a braconid wasp, *Apanteles papaipemae*, are probably the most important parasitoids of *Papaipema* (Decker 1930).

Conservation/management: Protection of known populations is essential to protect this species in Michigan. Almost all major workers on the genus have commented on the fire sensitivity of *Papaipema* eggs, and Decker (1930) highly recommends use of fire to control the pest species *P. nebris*. Land managers should heed Dana's (1986) general advice and always assume high mortality of *Papaipema* eggs in fall, winter, or spring burn units. To protect *Papaipema* populations, Schweitzer (1999) recommends protecting an adequate amount of the foodplant and to divide habitat into smaller burn units. No *Papaipema* site should ever be entirely burned in a single year. Foodplants spread over a large area or in several discrete patches reduce the risk from predators and parasitoids as compared to a comparable number of plants in a single dense patch. Most, if not all, of these parasitoids are native species and in most cases they do not need to be controlled. All known sites of *beeriana* on managed lands should be monitored periodically. There is no information to suggest how often this should be done and likely these surveys will be at the level of presence/absence, either of larvae or adults. Schweitzer does believe one could quantitatively sample larvae (or at least larval burrows) to estimate the actual size of a population. Monitoring is especially critical when planning to implement prescribed burns. Keep in mind that distribution of the *Papaipema* population among the various burn units will probably vary from year to year, so current information is needed. Generally decisions will be made on information from the previous growing season, since this is the best information on the distribution of *P. beeriana* eggs within a site.

Research needs: Major research needs, as outlined by Schweitzer (1999), include information on habitat requirements other than foodplants, on conditions under which females disperse, and on presence or absence of *Papaipema* on prairie preserves and other fire managed habitats. The latter is needed before dormant season burn regimens are implemented. Any information on speed of recolonization after prescribed burns would be useful. It would be important to try and document how recovery occurred, i.e., from other burn units, from outside the managed area, from skips in the burn, or from very wet microhabitats. More actual information on survival of *Papaipema* in mid or late summer burns is needed. More precise information as to what date *Papaipema* larvae have moved below ground is needed. This information can be used to better time burns, conduct mowing, or schedule grazing rotations. Information is needed to determine whether adults can locate suitable places for oviposition in foodplant patches burned or grazed earlier in the same season. For example, can adults (which typically occur October 1) find places to lay eggs in habitats burned in July or August. Information on how high eggs are placed on the host plant is needed so that the potential suitability of mowing as a management option can be evaluated.

Related abstracts: lakeplain prairie, prairie fen, pine barrens, culver's root borer moth

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Abstract citation

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Appendix 2. Landtype Associations (LTA) for the North Camp Grayling Pine Barrens Management Area

3511: Smooth ice-contact ridges, excessively drained sand or loamy sand.

General description: LTA 3511, which is concentrated in Crawford County, covers about 1% of Sub-subsection VII.2.2 (Table VII.2.2.B).

Glacial and bedrock geology: LTA 3511 occurs as ice-contact ridges.

Topography and soils: Broad, rolling ridges dominate the topography of the LTA, with localized occurences of steep-sided, ice-block depressions. Soils of LTA 3111 are deep, excessively drained sands in the Roselawn and Grayling series.

Presettlement vegetation: This LTA supported several of Michigan's most fire-dependent natural communities (Table VII.2.2.C and Appendix 7.2.2.A). Jack pine barrens (333) occurred on 59% of the LTA, and open grasslands, a relatively uncommon natural community in presettlement times, occurred on another 3%. Relatively pure forests of jack pine (4213) covered much of the remaining area, with isolated forests of red pine/jack pine (4215) and red pine/white pine (4216) occurring locally.

Present vegetation (MIRIS current land cover): Pine forests still cover about 49% of the LTA (Table VII.2.2.D and Appendix 7.2.2.B). However, pine barrens and grasslands have been nearly eliminated, with only a few scattered remnants persisting. Much of the herbaceous upland category, which covers 9% of the LTA, consists of weedy, unmanaged fields. Central hardwoods, with a high oak component, and aspen/birch forests, neither of which occurred here in presettlement times, now collectively cover most of the remaining area (40%).

Natural disturbance: Several large burned areas, which were associated with presettlement pine barrens and grasslands, were noted in General Land Office survey notes.

Lakes and streams: A few kettle lakes, usually smaller than 50 acres, are found in localized areas. Streams are a minor component of the landtype.

Threatened and endangered species and exemplary natural communities: Secretive locust, Hill's thistle, and rough fescue, all usually associated with jack pine barrens, occur within this LTA despite the fact that no high quality remnants of that community have been reported from the landtype (see Table VII.2.2.E). The federally endangered Kirtland's warbler, also reported from the LTA, is commonly associated with dense, thickets of jack pine. Further, one record for eastern massasauga, along with exemplary occurrences of intermittent wetland and poor fen, are reported from this LTA. The occurrence of these species and communities indicates that that LTA contains a wide range of habitats important for the maintenance of biodiversity in Michigan.

3111: Irregular ice-contact ridges; few kettle lakes; excessively drained loamy sand.

General description: LTA 3111, the third largest of 35 LTAs in Sub-subsection VII.2.2, covers about 11% of the sub-subsection (Table VII.2.2.B). Isolated units of the LTA occur within outwash plains throughout the sub-subsection.

Glacial and bedrock geology: LTA 3111 occurs on ice-contact ridges of sand and gravel.

Topography and soils: Topography is steep and irregular but rolling, pitted, or level areas occur locally. Slopes generally range between 6% and 45%, with the steepest areas occurring where ice-contact ridges rise from adjacent outwash plain. Soils of LTA 3111 are excessively drained gravelly sands, *e.g.* Roselawn, Rubicon, Graycalm, and Grayling series.

Presettlement vegetation: Almost 90% of the LTA supported conifer forests or barrens in presettlement times (Table VII.2.2.C and Appendix 7.2.2.A). The plant composition of the presettlement forests resulted from a variety of soil conditions and fire frequencies. Thus, forest types ranged from mixtures of eastern hemlock and white pine (4227) to pine and oak/pine barrens (333, 334, respectively). The most common forest types contained red pine, either mixed with white pine (4216), oak (4218), jack pine (4215), or locally in pure stands. Finally, where fires were least frequent, forests of American beech and sugar maple occurred; this was on about 8% of the LTA.

Present vegetation (MIRIS current land cover): Pine forests, which covered much of the LTA in presettlement times, now cover only about 12% (Table VII.2.2.D and Appendix 7.2.2.B). Another 30% of the area supports aspen/white birch forests, which did not occur here in presettlement Michigan. Finally, northern and central hardwood forests (both dominated by American beech and sugar maple but the later type with more oak) have increased from 8% presettlement cover to about 45% today.

Natural disturbance: GLO surveyors reported wildfires and windthrows, sometimes in combination, within this LTA. Evidently, wildfires often spread into this LTA type from adjacent outwash plains.

Lakes and streams: In general, lakes and streams are not an important component of LTA 3111. Locally, a few small kettle lakes occur along with the 80 acre Ogemaw Lake. The few streams that occur fall into two general types; small, low gradient and tightly meandering streams that flow through the valleys between ridges, and steep, narrow, ephemeral streams that dissect upland ridges.

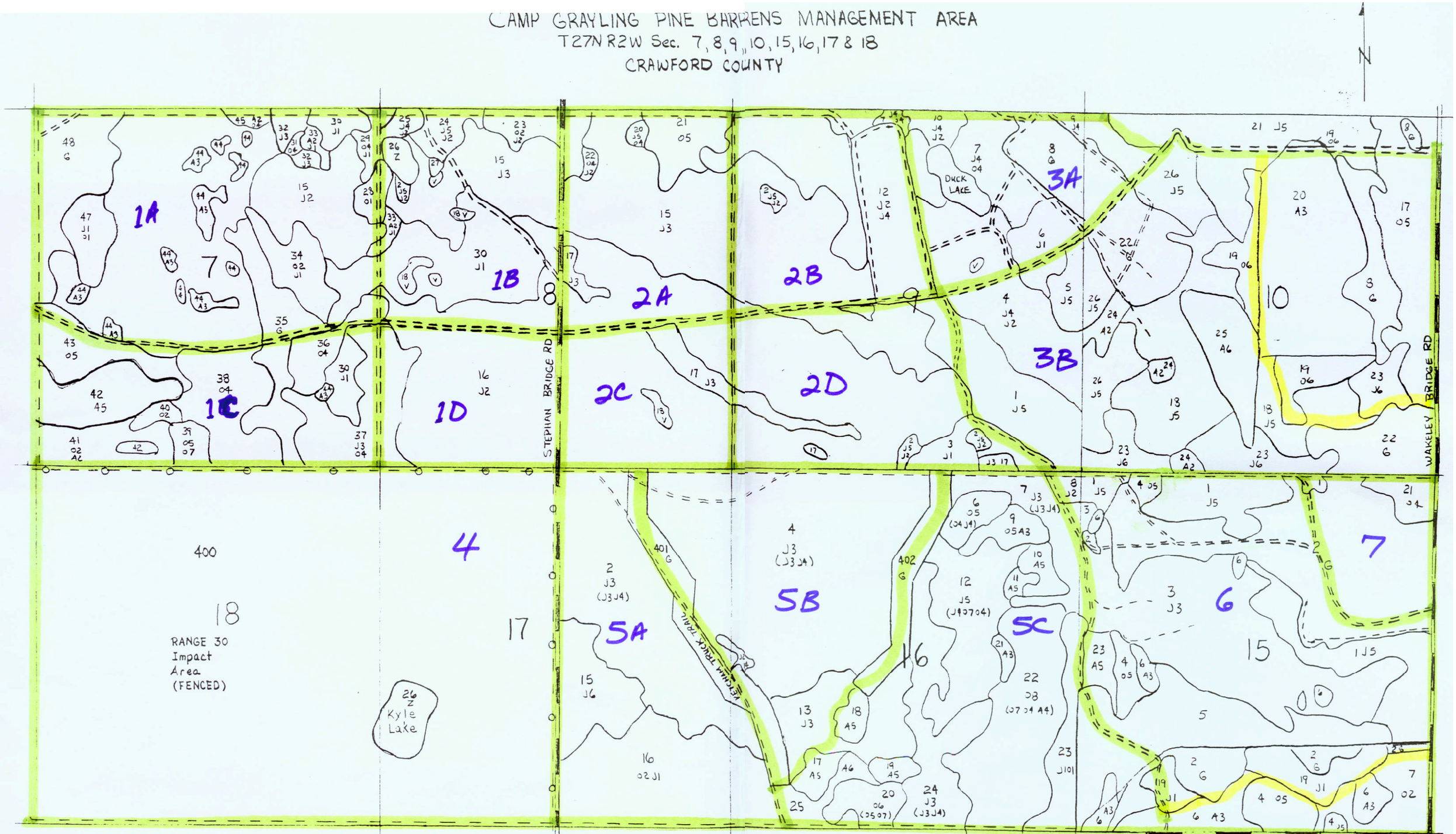
Threatened and endangered species and exemplary natural communities: The LTA supports numerous species of rare plants and animals, as well as several exemplary communities (Table VII.2.2.E). Most of the plants (pale agoseris, long-leaved aster, Hill's thistle, and Allegheny plum) and insects (secretive locust, grizzled skipper) are associated with dry, open to savanna-like communities. In contrast, the federally endangered Kirtland's warbler nests in thickety forests of jack pine, while spotted and wood turtles and the rare snail, boreal brachionyncha, use wetlands, streams, and cedar swamps.

Appendix 3. Operational Inventory Map for the North Camp Grayling Pine Barrens Management Area.

CAMP GRAYLING PINE BARRENS MANAGEMENT AREA

T27N R2W Sec. 7, 8, 9, 10, 15, 16, 17 & 18

CRAWFORD COUNTY



LEGEND

GRAVEL ROAD

TWO TRACK

FENCE

CONTENT

Compartment 253 Sections 7, 8 & 9
Compartment 254 Sections 16, 17 & 18
Compartment 261 Section 15
Compartment 262 Section 10

SCALE

1" = ¼ MILE

MAPPED BY C. FARRER
12-7-99

Appendix 3. Operational Inventory Map for North Camp Grayling Pine Barrens Management Area. Management units and sub-units are outlined in green. Yellow lines represent buffer areas

Appendix 4. Plant Species Abundance by Management Unit

Abundance ranks are as follows: D, dominant; LD, locally dominant; LC, locally common; C, common; O, occasional; R, rare; RL, rare and local. * Indicates the species was found exclusively in wet meadows.

Scientific Name	Common Name	Management Units						
		1	2	3	4	5	6	7
Aster lanceolatus	eastern lined aster	-	O*	-	-	-	-	-
Acer rubrum	red maple	-	-	D	-	-	-	-
Achillea millefolium		-	-	-	-	-	R	-
Agropyron repens	quack grass	R	-	-	O	-	-	LC
Agrostis hyemalis	Ticklegrass	O	O	-	-	LD/O	-	R
Amaranthus sp.	Pigweed	RL	-	-	-	-	-	-
Ambrosia artemisiifolia	common ragweed	RL	-	-	-	-	-	-
Amelanchier sp.	service berry	-	-	O	-	-	-	-
Amelanchier spicata	service berry	C	C	-	-	C	O	C
Andropogon gerardii	big bluestem	LD	LD	-	C	LD	LD	O
Antennaria sp.	pussy toes	-	-	-	-	-	O	R
Apocynum androsaemifolium	Dogbane	O	O	-	-	R	-	-
Arabis glabra	tower mustard	-	-	-	O	-	-	-
Arctostaphylos uva-ursi	bear berry	LD	LD	-	-	LD	LC	LD
Artemisia campestris	Wormwood	R	-	-	O	-	-	-
Asclepias syriaca	common milkweed	-	-	-	O	-	-	-
Aster laevis	smooth aster	O	O	-	O	O	O	C
Aster ptarmicoides	upland white goldenrod	-	-	-	-	R	-	O
Bromus kalmii	brome grass	O	O	-	O	-	-	-
Bromus pubescens	Canada brome	-	-	-	-	-	R	-
Calamagrostis canadensis	blue-joint grass	-	LC*	-	-	-	-	-
Campanula rotundifolia	harebell	O	O	-	-	O	O	O
Carex lasiocarpa	sedge	C*	LD*	-	-	-	-	-
Carex oligosperma	sedge	C*	-	-	-	-	-	-
Carex pensylvanica	Pennsylvania sedge	C	C	C	C	LC	LC	D
Carex stricta	sedge	-	-	-	-	-	R	-
Carex stricta	sedge	-	LC*	-	-	-	-	-
Ceanothus sp.	new jersey tea	R	R	-	-	LD	-	-
Centaurea maculosa	spotted knapweed	R	-	-	O	R	-	R
Chamaedaphne calyculata	leatherleaf	C*	-	-	-	-	-	-
Chenopodium album	lamb's quarters	RL	-	-	-	-	-	-
Cirsium hillii	hill's thistle	R	R	-	R	R	-	R
Comptonia peregrina	sweet fern	C	C	-	C	O	O/C	LC
Conyza canadensis	horseweed	-	-	-	O	-	-	-
Cornus foemina	gray dogwood	-	LC*	-	-	-	-	-
Crataegus sp.	crab apple	O	O	-	-	-	-	O
Danthonia spicata	poverty grass	LD	LD	-	LD	O	LD	D
Deschampsia flexuosa	hair grass	C	C	O	C	D/C	LC	C
Eleocharis elliptica	golden-seeded spike-rush	-	LC*	-	-	-	-	-
Epigaea repens	trailing arbutus	LC	LC	C	O	-	LC	-
Eragrostis sp.	love grass	RL	-	-	-	-	-	-
Erigeron sp.	Fleabane	-	O*	-	-	-	-	-
Euthamia graminifolia	grass leaved goldenrod	C*	-	-	-	-	-	-
Festuca ovina	sheep fescue	-	-	-	C	-	-	R

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Scientific Name	Common Name	Management Units						
		1	2	3	4	5	6	7
Festuca scabrella	rough fescue	R	LC	-	R	R	R	-
Fragaria virginiana	strawberry	O	O	-	-	-	-	-
Gaultheria procumbens	wintergreen	-	-	C	-	O	LC	-
Gaylussacia baccata	huckleberry	-	-	-	-	-	O	-
Gentiana procera	small fringed gentian	-	O*	-	-	-	-	-
Glyceria canadensis	Canada rice grass	-	O*	-	-	-	-	-
Glyceria striata	fowl manna grass	-	-	R	-	-	-	-
Hamamelis virginiana	witch hazel	-	-	R	-	-	-	-
Helianthemum sp.	frostweed	-	-	-	-	-	-	O
Helianthus occidentalis	western sunflower	O	O	-	-	-	-	O
Hieracium scabrum	hawkweed	-	-	-	-	-	O	-
Hieracium spp.	hawkweed	C	C	-	-	-	-	O
Hieracium venosum	rattlesnake weed	-	-	-	-	O	-	-
Hypericum perforatum	common St. john's-wort	C	C	-	-	-	-	LC
Iris versicolor	wild iris	-	O*	-	-	-	-	-
Juncus effusus	soft-stemmed bulrush	-	LC*	-	-	-	-	-
Koeleria macrantha	june grass	O	O	-	-	-	-	-
Lechea intermedia	pinweed	-	-	-	-	-	-	O
Lepidium sp.	pepper-grass	RL	-	-	-	-	-	-
Liatris scariosa	blazing star	O	O	-	-	O	-	O
Lilium philadelphicum	wood lily	R	-	-	-	-	-	-
Lithospermum caroliniense	yellow puccoon	-	-	-	-	R	-	-
Lobelia spicata	pale spiked lobelia	-	O*	-	-	-	-	-
Lycopodium annotinum	club-moss	-	-	-	-	-	O	-
Lycopodium digitatum	club-moss	-	-	-	-	-	O	-
Lycopodium obscurum	club-moss	-	-	O	-	-	O	-
Lycopus uniflorus	northern bugleweed	-	O*	-	-	-	-	-
Maianthemum canadense	Canada mayflower	-	-	C	-	O	C	-
Melampyrum lineare	cow-wheat	-	-	O	O	-	-	-
Oryzopsis asperifolia	rice-grass	O	O	LD	-	O	O	-
Oryzopsis pungens	rice-grass	C	C	-	C	O	R	O
Panicum sp.	panic grass	C*	-	-	-	-	-	-
Panicum capillare	witch grass	RL	-	-	-	-	-	-
Panicum spp.	panic grass	C	C	C	-	-	-	C
Pedicularis canadensis	wood betony	-	-	O	-	-	-	-
Pinus banksiana	jack pine	D	D	C	D/C	D	D	O
Pinus resinosa	red pine	R	R	-	C	-	-	-
Poa compressa	Canada bluegrass	-	-	-	-	-	R	R
Poa pratensis	Kentucky bluegrass	-	-	O	LC	LC	-	-
Polygonella articulata	joint weed	-	-	-	O	-	-	-
Polygonum amphibium	water smartweed	-	O*	-	-	-	-	-
Populus grandidentata	big-toothed aspen	-	-	O	-	-	-	-
Populus tremuloides	trembling aspen	O	O*	O	-	O	R	R
Potamogeton gramineus	pondweed	-	O*	-	-	-	-	-
Potentilla anserina	silverweed	-	LC*	-	-	-	-	-
Potentilla argentea	silvery cinquefoil	-	-	O	O	-	-	-
Potentilla simplex	common cinquefoil	-	-	-	-	-	-	C
Prunus pumila	sand cherry	LD/ C	LD/C	-	LC	C	-	LD

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Scientific Name	Common Name	Management Units						
		1	2	3	4	5	6	7
Prunus serotina	black cherry	O	-	-	O	-	O	O
Pteridium aquilinum	bracken fern	O	O	D	O	O	-	O
Quercus alba	white oak	-	-	D	-	-	-	-
Quercus ellipsoidalis	northern pin oak	O	O	O	C	O	O/C	R
Quercus rubra	red oak	R	-	-	-	-	-	-
Rubus flagellaris	northern dewberry	O	O	-	O	O	-	O
Rubus hispidus	swamp dewberry	O*	O*	-	-	-	-	-
Salix exigua	sandbar willow	C*	LC*	-	-	-	-	-
Salix humilis	prairie willow	-	O*	-	C	-	O	O
Salix petiolaris	slender willow	-	C*	-	-	-	-	-
Schizachne purpurascens	false melic	LC	-	-	LC	-	LC	-
Schizachyrium scoparius	little bluestem	LD	LD	-	C	O	C	C
Scirpus acutus	hardstem bulrush	-	LC*	-	-	-	-	-
Scirpus cyperinus	wool-grass	C*	O*	-	-	-	-	-
Setaria sp.	foxtail	RL	-	-	-	-	-	-
Solanum ptycanthum	black nightshade	RL	-	-	-	-	-	-
Solidago altissima	tall goldenrod	-	LC*	-	-	-	-	-
Solidago hispida	hairy goldenrod	O	O	-	O	O	O	O
Solidago juncea	early goldenrod	O	O	-	-	-	-	-
Solidago nemoralis	gray goldenrod	-	-	-	-	O	O	C
Solidago simplex	Gillman's goldenrod	O	O	-	-	-	-	-
Solidago speciosa	showy goldenrod	-	-	-	-	O	-	-
Sorghastrum nutans	Indian grass	O	O	-	O	O	-	-
Sphagnum sp.	sphagnum	-	-	-	-	-	R	-
Spiraea alba	meadowsweet	C*	LC*	-	-	-	-	-
Sporobolus cryptandrus	dropseed	-	-	-	O	-	-	-
Vaccinium angustifolium	low sweet blueberry	LC	LC	LD	LC	LD	LD	LD
Vaccinium myrtilloides	Canada blueberry	-	-	-	-	-	-	O
Verbascum thapsus	mullein	-	-	-	O	-	-	-
Viola pedata	bird's foot violet	-	-	-	-	O	-	-
Viola sp.	violet	-	O*	-	-	-	-	-
-	lichens	C	C	-	R	LD	C	LD
-	moss	-	-	-	-	LD	LD	-
Total number of species		65	67	26	42	44	44	48

Appendix 5. Spotted Knapweed Stewardship Abstract

ELEMENT STEWARDSHIP ABSTRACT

for

Centaurea maculosa (Spotted Knapweed)

To the User:

Element Stewardship Abstracts (ESAs) are prepared to provide The Nature Conservancy's Stewardship staff and other land managers with current management-related information on those species and communities that are most important to protect, or most important to control. The abstracts organize and summarize data from numerous sources including literature and researchers and managers actively working with the species or community.

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The Nature Conservancy
Element Stewardship Abstract
For *Centaurea maculosa*

IDENTIFIERS

Common Name: Spotted Knapweed

General Description: The following description of *Centaurea maculosa* is taken from Munz and Keck (1973) and Roche et al. (1986).

C. maculosa is a biennial or short-lived perennial composite with a stout taproot. It has 1-20 slender, upright stems, 3-10 dm tall, most branching in the upper half. Seedling leaves form a rosette; stem leaves are canescent, the lower once or twice pinnately divided into linear or lanceolate lobes on each side of center vein, tapered at both ends, the broadest part above the middle to 10 cm long and 3 cm wide; the upper with fewer lobes or entire, becoming smaller up the stem to less than 1 cm long. Heads are solitary, terminal, egg-shaped to oblong, 1.5-2.5 cm broad and 1.3cm tall. The involucre is pale and 1-1.4 cm high. Phyllaries are not spiny but have obvious veins, the lower and middle bracts egg-shaped, green to brown, all with a dark pectinate tip and the upper margin fringed with 5-7 pairs of cilia. The slender tubular flowers are whitish to pink or purplish; the marginal florets somewhat enlarged. Seeds are oval, brown to black with pale lengthwise lines; the pappus copious and whitish.

C. maculosa resembles other species in the genus, including *C. diffusa* (diffuse knapweed), *C. nigra* (black knapweed), *C. jacea* (brown knapweed), *C. nigrescens* (short-fringed knapweed), and *C. trichocephala* (featherhead knapweed). The best way to distinguish *C. maculosa* is by the dark tips and fringed margins of its phyllaries. All of these species are capable of becoming serious weed problems.

STEWARDSHIP SUMMARY

NATURAL HISTORY

Habitat: A native of Europe, *C. maculosa* was accidentally introduced to North America most likely in the 1890s in alfalfa seed from Asia Minor (Maddox 1979). Spotted knapweed was collected in Victoria, B.C. in 1893 (Moore and Frankton 1974). It is assumed that soil carried on ships as ballast and unloaded in the port transported knapweed seed to this site at that time (Roche et al. 1986). Although the earliest collections of *C. maculosa* are from coastal areas of British Columbia and Washington, evidence of observed densities and directions of spread suggest it has moved into Washington more rapidly from the east (Roche et al. 1986). This species was abundant in Montana before it became common in Washington (Roche et al. 1986).

Approximately 1.5 million ha of pasture and rangeland in Washington, Montana, Idaho, Oregon and California are infested with knapweed, and it threatens 10.7 million ha in western Canada (Harris and Cranston 1979). Inceptisol soils are susceptible to spotted knapweed invasion in western Canada (Harris and Cranston 1979). In 1988, Alberta reported 145 sites of scattered individuals (Ali 1988). British Columbia reported that 100,000 acres were presently occupied by *Centaurea* species, and 2.7 million acres could potentially be infested.

Diffuse knapweed accounted for 75% of that total area infested, with spotted knapweed accounting for the second largest area (Cranston, 1988). In Montana spotted knapweed occupies 4.7 million acres (Lacey 1988), the largest area in one state or province. There it appears best adapted to well-drained, light-textured soils that receive summer rainfall, including habitats dominated by Ponderosa pine and Douglas fir, as well as foothill prairie habitats with bluebunch wheatgrass, needle-and-thread, and Idaho fescue (Chicoine 1984). In Washington, spotted knapweed rates third among the state's knapweeds, with four percent of the total acreage.

It is reported in 19 counties, with a total area of 10,777 ha. Ninety-two percent of the spotted knapweed is found in three northeastern counties (Roche and Roche 1988). Thirty-nine percent (4,253 ha) grows on land classified as industrial, including gravel pits, stockpiles, power lines, grain elevators, railroad, and equipment yards. These are strategic seed distribution points (Roche and Roche 1988). Seventeen percent occurs on pasture, range, and timbered range, and sixty-eight percent of this pasture-range-timbered range total is on pasture (Roche and Roche 1988). In the counties that reported few infestations, the plants were almost exclusively along roads or in urban areas. In central Washington, it is often associated with irrigation, preferring areas of high available moisture, including areas of deep soil with threetip sagebrush/fescue and roadsides receiving runoff (Roche et al. 1986). *C. maculosa* occurs statewide as individuals or small colonies in North Dakota, and on at least 32 sites in 10 counties in Utah. In Oregon, it grows on 121,600 acres in 23 counties. Spotted knapweed seems to occur along the more mesic margins of the range of the more widely distributed diffuse knapweed (*Centaurea diffusa*) (personal communication, Larry Larson).

Reproduction: The biology and North American distribution of spotted knapweed are described in Reed and Hughes (1970), Moore (1972) and Watson and Renney (1974). Seeds germinate in fall and early spring. Thirty percent of seeds may be viable after eight years of burial (Davis and Fay 1991). Seedlings form rosettes which may produce 1-7 flowering stems the following spring. Marked plants in the Glacier National Park area in Montana have been observed to persist in the rosette stage for four years or longer before bolting (Tyser, personal observation, in Tyser and Key 1988). Plants may flower only once, or up to three years in succession, and perennial plants may have up to 20 flowering stems. Each plant produces 4-5 capitula in the first year (range 1-25), and 8-15 capitulas (range 1-89) in succeeding years. In central Oregon capitula are visible on the plants in late June; flowers open from mid/late July until mid August. Knapweeds are cross pollinated by insects, but are also self-compatible (Lack 1982).

Estimates of the mean number of achenes (seeds) per capitula range from 9-37 in the literature (Watson and Renney 1974, Schirman 1981, Harris 1980b, Maurer et al in prep). Variations in numbers of stems, capitula, and seeds have been observed between sites and years, and were attributed to seasonal differences in precipitation (Schirman 1981). Up to 146,000 seeds per square meter have been reported using calculations based on seed capitula density and seed numbers (Schirman 1981). Dispersal is generally passive, occurring in late summer (but may continue throughout the fall, winter and spring), as seeds are shaken from drying capitula. The short pappus and weight of the seed (1.7 mg) keep dispersal distances relatively short; seeds generally fall within a 3-12 dm radius of the parent plant (Roche et al 1986). Existing populations spread outward at the perimeter and downwind (Roche et al 1986). Movement over greater distances requires transport by rodents, livestock, vehicles, or hay or commercial seed (Roche et al 1986).

Spotted knapweed seeds may germinate over a wide range of soil depths, soil moisture content and temperatures (Spears er al 1980, Watson and Renney 1974). Seed dormancy may be induced by exposure to light (Watson and Renney 1974)? Seedlings emerging early in the season (April and May) have a high probability of survival and reproduction in the following year. Those emerging in June and July have a low survival rate and almost no stem production the following season (Schirman 1981). Schirman (1981) estimated that survival of only about .1% of seed production is required to maintain stands at observed plant densities in highly disturbed areas.

In seed sowing studies Roze et al (1984) found that rosettes and bolting plants appeared on plots sown at densities as low as 208 seeds per m^2. Numbers of bolted plants were lower in plots with higher seed and rosette densities, possibly due to intraspecific competition. At low densities, the average number of capitula per plant tended to increase, although differences were not significant for the number of plots used in this study.

Lateral root-sprouting in *C. maculosa* may result in rosettes that may remain attached to the parent for an indefinite length of time, but expansion of a colony is primarily dependent upon seed production (Tyser and Key 1988).

The competitive superiority of this species suggests preadaptation to disturbance (Roche et al 1986). The

initial invasion of spotted knapweed, like other noxious weeds, is correlated highly to disturbed areas. Once a plant or colony is established though, it may invade areas that are relatively undisturbed or in good condition with gradual, broad, frontal expansion (Tyser and Key 1988, Lacey et al 1991). This invasion is associated with a decline in the frequency of some species and a decline in species richness overall (Tyser and Key 1988). Widespread invasion of spotted knapweed often results from overgrazing. It has a low palatability, as it contains a bitter compound cnicin (Roche 1990). As the native grasses and forbes are continually eaten, the food reserves of their roots are depleted, and they are less able to compete with the knapweed (Roche 1988). The knapweed is highly adept at capturing available moisture and nutrients, and it quickly spreads, choking out other vegetation (Roche et al 1986). As the network root system of the native species is lost, replaced by the taproot of the knapweed, the water storage capacity of the soil decreases (Roche 1988), and soil erosion increases (French and Lacey 1983, in Tyser and Key 1988). Lacey et al (1988) compared two elements of erosion on plots that were 90% bunchgrasses to plots that were 85% spotted knapweed. The average total runoff from the bunchgrass plots was 23%, and the average sediment yield was 39 pounds per acre. The total runoff from the knapweed plots averaged 36%, and the total sediment yield averaged 114 pounds per acre.

Although the quality of the land being invaded does not seem to be able to exclude spotted knapweed, it probably does effect the rate of spread of the infestation. In a study conducted in Glacier Nation Park, the front of a *C. maculosa* colony advanced by 10 meters in three years ((Tyser and Key, 1988). In another study, also conducted in Montana, the front of a colony advanced 14 meters in four years (Lacey et al 1991).

CONDITION

MANAGEMENT/MONITORING

Management Requirements: Most literature on controlling knapweed has focused on reestablishing valuable range, pasture, or cropland. None has looked at the problem from the point of view of restoration ecology, with the intent of restoring the native community.

Spotted knapweed is increasing in its range and frequency in western North America. It is important to monitor whatever means of control are used in order to determine the efficacy of the efforts and the effects of control upon the larger community.

The extent of infestation can be monitored with either low altitude aerial photographs or permanent photo plots. A permanent line transect should be established so that plant and/or stem density can be measured. The transect should extend outside the colony in order to measure the direction and rate of change in the size of the colony. If biological control agents are used, sticky traps and capitula dissection should be used to monitor insect populations, attack rates, and seed losses.

There are several methods of control for this species. It is important to determine and document the methods most effective for different sized infestations, different communities, and the specific characteristics of the site, including soil type, exposure, drainage, and degree of disturbance, human or otherwise.

Control of this species is receiving considerable attention by state agencies as well as colleges and universities in Oregon, Washington, Idaho and Montana. This species is very aggressive. In addition to the effects it could have on elements, control of this species is mandated by county and state agencies. In most states and provinces it is under the "A" weed list for eradication.

Several grasses and forbs, most of them non-native, have been used to explore the possibility of replacing *Centaurea* species by the seeding of a competitor. A. H. Bawtree, Provincial Range Specialist in British Columbia cited a group of studies from which he recommended the application of picloram at no more than 6 oz. per acre followed by fall seeding of crested wheatgrass (Bawtree 1988). An Oregon State University study found six species--Palestine orchardgrass, Berber orchardgrass, Nangeela subterranean clover, Mt. Baker subterranean clover, and Covar sheep fescue--that over the course of six years were able to establish themselves and outcompete yellow starthistle (*Centaurea solstitialis*)

(Johnson 1988). A two-year study of four grasses--Paiute orchardgrass, Covar sheep fescue, Critana thickspike wheatgrass, and Ephriam crested wheatgrass--found that the greater the biomass produced by the grass, the more it reduced the number of diffuse knapweed (*Centaurea diffusa*) seedlings. The species are listed in the order of their effectiveness. The researcher also indicated that those species whose growth period overlap the growth period of diffuse knapweed would be more effective at competing for moisture and nutrients (Larson, 1988).

Mowing is a method of control that would be possible only in areas that are not too rocky or steep, or without shrubs. If mowed in the early flowering state, the plants will usually regrow and produce abundant late season seeds. Those mowed even the same day as florets appear out of the bud have enough energy to produce seed. Among those mowed within ten days after flowerheads opened, none produced more than four filled seeds per head, and the greatest viability of these filled seeds was 57%, reached nine days after the flowerhead opened. Although these results indicate that mowing greatly reduces the seed set, a well established seed bank, such as would be present on a large or severe infestation, would most likely be able to compensate for this loss. Mowing would probably be a way to control populations, but not eradicate them.

No detailed research on vegetation response to knapweed control exists in the literature. The use of seeded or planted native bunchgrass species has not been explored. No studies have explored control by timed removal of flower capitula. Most studies have been designed to tackle infested areas on a large scale, and scale might prohibit removal of capitula by manual methods. However, relatively small areas that might be encountered on TNC preserves may be more amenable to this sort of management. Documented successful control in small areas by capitula removal would add valuable new information to the control literature.

Chemical and biological control have been proposed for spotted knapweed, and most of the control literature addresses these two categories:

Herbicides--*C. maculosa* can be controlled with picloram (4-amino- 3,5,6-trichloropicolinic acid) and 2,4-D but there are problems. Control by 2,4-D is temporary since it does not prevent germination from seeds in the soil. Picloram persists in soils but in 4 years, enough is lost from a .4-.6 kg/ha treatment to allow germination and reinfestation (Harris and Cranston 1979). The costs of applying picloram are estimated at $37/ha, and are prohibitive for very large infested areas (Maddox, 1979).

Biological--Four insect species have been introduced into North America for biological control of knapweeds. Two gall flies, *Urophora affinis* and *Urophora quadrifasciata* (Diptera: Tephritidae) (Maddox 1982, Story and Anderson 1978, Harris 1980 a and b, Myers and Harris 1980, Berube 1980) and a moth, *Metzneria paucipunctella* (Lepidoptera: Gelechiidae) attack seed capitula (Englert 1971, Myers personal communication). A beetle which attacks the roots, *Shenoptera jugoslavica* (Coleoptera: Buprestidae) has also been introduced more recently (Zwolfer 1976).

U. affinis lays its eggs into young buds of *C. maculosa*. Egg hatch is synchronized with rapid growth of the receptacle in which each larva forms a gall. The seeds are not destroyed directly, but the diversion of nutrients to the gall reduces seed production by the plant as a whole (Harris 1980b). One generation of flies per season is usual, but a small proportion of the population completes a second one. Reported percentages of capitula attacked range from 10-50%, with up to 97% reduction in seed numbers per capitula.

U. quadrifasciata lays its eggs into florets inside more mature buds. Both species of *Urophora* can coexist in the same capitula. Some studies (Harris 1980) have found that *U. quadrifasciata* may attack capitula missed or more lightly-attacked by the earlier-attacking *U. affinis*, and result in a higher overall attack rate among capitula.

Metzneria paucipunctella lays eggs at the base of spotted knapweed buds and a young larva bores into the capitula after hatch. It feeds first on florets, then directly on seeds and does not form a gall. Establishment of this species has been somewhat difficult and increase has been slower than the fly species.

Female Sphenoptera beetles oviposit at the base of C. maculosa rosettes, and first instar larvae feed

externally on plant tissues. After the first molt, the larva enters the plant tissue and mines into the root. A gall forms as the rosette terminates aestivation and resumes growth. The larva overwinters in the rosette root and pupates the next spring in a pupal chamber in the root crown. Adult beetles emerge and feed on knapweed leaves adding to the root damage imposed by larvae.

Insects are available from USDA sources and could be released in target areas as a first step for control with relative ease and at no or little cost. Seed capitula attack percentages seem to rise quickly within a few years, but noticeable decreases in reproductively mature plants will take longer because of seed bank reserves and dormancy. This method, though slower, may be desirable because of minimal disturbance to soil and surrounding vegetation.

Other methods of control should be explored:

Mowing--although this would not be feasible in rocky, or sagebrush areas, in some knapweed stands with little other vegetation it might be possible to mow the plants just after most flowering has ended but before seeds have matured. This would make regrowth unlikely since moisture levels late in the season are probably too low for continued growth, but would offer a possible advantage of reducing reserves for flowering the following year.

Hand Removal--by August, in central and eastern Oregon, soils are often dry and dusty, and it may be possible to pull up a large number of seedlings, rosettes and reproducing plants in a small infested area. However, effects of soil disturbance on knapweed seed germination are not well documented. Even if seed germination of knapweed were not a problem, colonization by other weed species may be.

Hand Clipping--This method might alleviate the soil disturbance problem outlined above. Again, this would probably be feasible only in small infested areas. Timing would be the same as mowing and the stems and capitula would be removed from the area. Again, control might be slower, due to continued emergence from seedbank reserves.

Burning--although no literature specifically mentioned this as a control method for knapweed, it might be considered in areas with enough surrounding vegetation or litter to carry a controlled burn. Often however, dense stands of knapweed have little surrounding vegetation, possibly due to allelopathy. Litter from the previous year's stems often decays or scatters during the current season, but it may accumulate in very dense stands and create more favorable burning conditions.

RESEARCH

Management Research Programs: Identify infestations on or near preserves. Experiment with manual control methods.

ADDITIONAL TOPICS

INFORMATION SOURCES

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Appendix 6. Random Numbers Table

Table of 2500 random digits

	1	2	3	4	5	6	7	8	9	10
1	60376	41323	10602	84340	97576	14805	69707	34921	11452	89438
2	46344	10584	86683	02566	59480	34903	61581	16089	77070	79343
3	11577	79947	79334	19687	72005	08246	94827	11038	09763	25898
4	79776	71419	69714	73749	90832	90525	60745	17334	84458	69887
5	88381	32563	75479	91241	15556	62030	41107	29745	93562	88343
6	13009	84319	77412	89187	58018	39591	80415	28603	93685	74322
7	49316	44183	60559	72445	14822	08810	29063	37372	69733	31885
8	47701	80753	22342	76483	14470	74841	58861	04390	04337	88612
9	02948	21516	95297	47774	95884	46751	80942	81505	90039	95767
10	53148	21995	63997	33310	19361	48845	87898	56087	91714	63928
11	66202	71682	03865	40517	95123	43331	09323	60432	33965	41987
12	49492	59072	67053	63209	24632	56593	90649	75136	48400	74792
13	13502	23531	56422	52511	93697	66070	33200	19124	53840	32666
14	21458	78318	88507	59147	64985	43603	99845	14705	81003	11737
15	38873	96083	34733	82055	09075	40685	01276	55192	19364	62245
16	41964	63834	51605	91263	31617	92339	45753	05079	47958	49576
17	87556	51127	21624	63282	95205	39780	68460	65065	36240	23739
18	53369	93827	32658	73488	11004	84691	07915	53416	85227	81272
19	69363	43307	78274	06400	42180	96428	30566	69563	12026	39682
20	87558	66341	48344	57160	22925	68337	15265	50322	20695	38560
21	79096	92110	12017	81044	97960	40774	66911	65219	25084	82449
22	73534	90938	63039	14456	06097	85965	71585	43488	93409	18633
23	88933	02237	01572	58228	66326	08420	30472	95632	26707	62281
24	99675	93366	28678	42886	46069	09087	41043	84618	72216	60322
25	39274	02705	86720	83909	84877	18450	08975	73718	34665	38112
26	73466	61357	02432	54726	35481	91591	48021	85464	20485	53800
27	49442	21959	77024	83766	25709	72376	83526	99090	86024	20027
28	71257	68216	44327	50333	85955	29860	27501	05179	13378	95466
29	24541	01149	99395	52260	53832	48970	13776	49302	42387	00472
30	65399	15073	30719	25625	61541	35447	33964	24886	04376	39348
31	57637	34326	01753	80545	26566	64584	26235	61581	41486	28191
32	01981	19261	61826	26526	88320	60620	38824	96307	55201	13945
33	97781	21645	14204	18095	00626	45729	06731	34541	56411	67633
34	06536	91314	23075	25371	26115	60628	22190	26073	92891	05421
35	46414	07876	28902	04259	19006	73775	51142	11155	13487	15454
36	81227	71202	51022	89388	31673	37226	43824	75347	74379	38181
37	75906	88152	26852	50317	34046	56891	54874	64043	90902	04262
38	52662	74121	06956	69998	13070	66169	67148	77079	81942	24962
39	83495	56621	17099	62681	74344	08386	53274	61216	02891	42179
40	06393	23487	80390	72358	96505	35521	74803	64273	91684	98430
41	54305	48554	19490	26058	63162	00647	15526	41075	27851	10990
42	11433	47104	70717	54571	65442	73267	39542	53443	89024	12559
43	49311	74489	40979	74732	77329	01213	78356	21481	19985	83143
44	78195	40631	25735	21358	74981	90268	26448	36823	86002	91170
45	15852	85711	21148	61829	98636	40353	17134	83339	34208	86416
46	22282	47250	30926	53721	80177	09590	75077	78055	39089	95241
47	94380	24033	75527	96829	36372	81284	18322	74222	64408	14918
48	43657	26791	79936	06855	98707	40433	41124	44914	97490	24064
49	36968	73084	90047	13133	76497	61749	71253	70992	07913	52007
50	18221	17440	23245	28464	86977	12326	44269	70810	87439	76739

Appendix 7. 1999 Monitoring Data for Rough Fescue and Hill's Thistle

Rough Fescue (*Festuca scabrella)* Monitoring Data

TRANSECT										
Quadrat	1	2	3	4	5	6	7	8	9	10
1										
2	X									
3	X	X								X
4		X	X	X						
5	X		X	X	X	X				X
6	X	X	X	X	X	X	X	X	X	
7		X	X				X			
8			X	X	X			X	X	X
9		X	X							X
10				X	X	X	X	X	X	X
TOTAL	4	5	6	5	4	3	3	3	3	5
Total number of quadrats that species is present in: 41							Total % frequency*: 41			

*% frequency = total number of quadrats that species is present in.

Number of Hill's thistle (*Cirsium hillii*) rosettes by length of longest leaf (cm).

Length	2	3	4	5	6	7	8	9	10	11	12	13	14	15
# of individuals	2	7	8	8	7	11	4	2	4	2	1	1	0	1

Appendix 8. Rare Plant Monitoring Data Sheets

Date:_____

Environmental Conditions:

_____

_____

General Observations (exotic species, herbivores?, pollinators? seed dispersal agents?, etc.):

_____

_____

_____

_____

TRANSECT										
Quadrat	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
TOTAL										
Total number of quadrats that species is present in:							Total % frequency*:			

*% frequency = total number of quadrats that species is present in.

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Cirsium hillii Monitoring Data Sheet
TOTAL COUNT OF INDIVIDUALS IN COLONY

Date:_____

Environmental Conditions:
_____
_____

General Observations (exotic species, herbivores, pollinators, seed dispersal agents, etc.):
_____
_____

1. Record length (cm) of longest rosette leaf for each individual:
   If flowering record number of flowering heads

Leaf length (cm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
# of individuals																	

Leaf length (cm)	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
# of individuals																	

2. Tally size classes. Seedlings: rosette leaf 1– 4 cm
   Juveniles: non-flowering; rosette leaf > 4 cm
   Adults: flowering plants

Life stage	Seedlings	Juveniles	Adults	Total Ind.
# of individuals				

3. Record number of flowering heads per adult.

Adult	1	2	3	4	5	6	7	8	9	10
# of flowering heads										