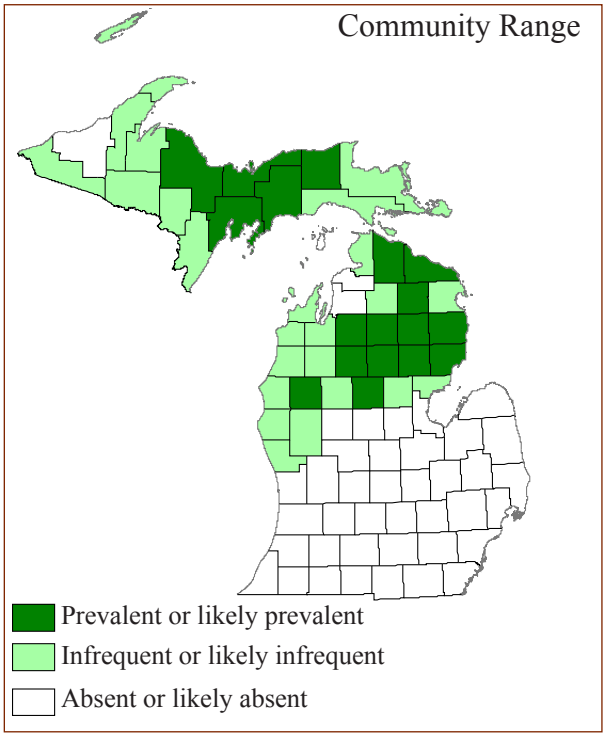
Dry Northern Forest — Community Abstract

Photo by Joshua G. Cohen



Overview: Dry northern forests are pine- or pine-hardwood-dominated communities found on dry sand soils and occurring principally on sandy glacial outwash and sandy glacial lake plains and less often on sand ridges in peatland complexes on glacial outwash or glacial lake plains. Two distinct variants are included within this community type; jack pine/jack pine–hardwood–dominated and red pine–dominated. Prior to European settlement, dry northern forest typically originated in the wake of catastrophic fire, and frequent, low-intensity ground fires maintained red pine systems.

Global and State Rank: G3?/S3

Range: Dry northern forest has existed as a dominant assemblage in the central Great Lakes region of the United States and Canada for approximately 5,000-8,000 years, following the peak of the last interglacial warming trend (Davis 1976). The community occurs in northern Michigan, Minnesota and Wisconsin and in southern portions of Manitoba and Ontario (NatureServe 2001). Within Michigan, this forest type is predominantly found in the northern half of the Lower Peninsula above the transition zone and throughout the Upper Peninsula. Presently the distribution of dry northern forest is most heavily concentrated in the Grayling, Newaygo, Baraga, Raco and Yellow Dog Outwash Plains.

Rank Justification: In the Great Lakes region, widespread selective logging of white pine, red pine and hemlock at the end of the 19th century and the beginning of the 20th century followed by extensive slash fires resulted in an increase in the acreage of mature dry northern forest dominated by jack pine (Cayford 1970, Cayford and McRae 1983). However, dry northern forests dominated by red pine or containing a significant canopy component of red pine were greatly diminished. Logging and subsequent slash fires eliminated potential red pine seed trees, killed advanced regeneration and incinerated residual seed in the duff (Collins 1958, Curtis 1959). Slash fires were extremely hot due to the combustion of resinous pine wood and fires often burned deeply into the ground, destroying the organic surface soil, consuming humus and creating barren stump plains (Reimann 1982) and scrub oak lands (Kittredge and Chittendon 1929). Where fire was less intense or absent, stands of early successional jack pine, bigtooth aspen, trembling aspen and/or white birch dominated following the logging (Sakai et al. 1985). Beginning in the 1920s, effective fire control by the U.S. Forest Service and state agencies reduced the acreage of forest fires ignited by humans or lightning (Swain 1973). With fire prevention, jack pine forests have decreased by nearly 25,000 acres across the Lake States (Johnson 1994), although fire suppression in pine barrens has resulted in their conversion to dry northern forest. As a result of fire exclusion, many stands of dry northern forest are suc-

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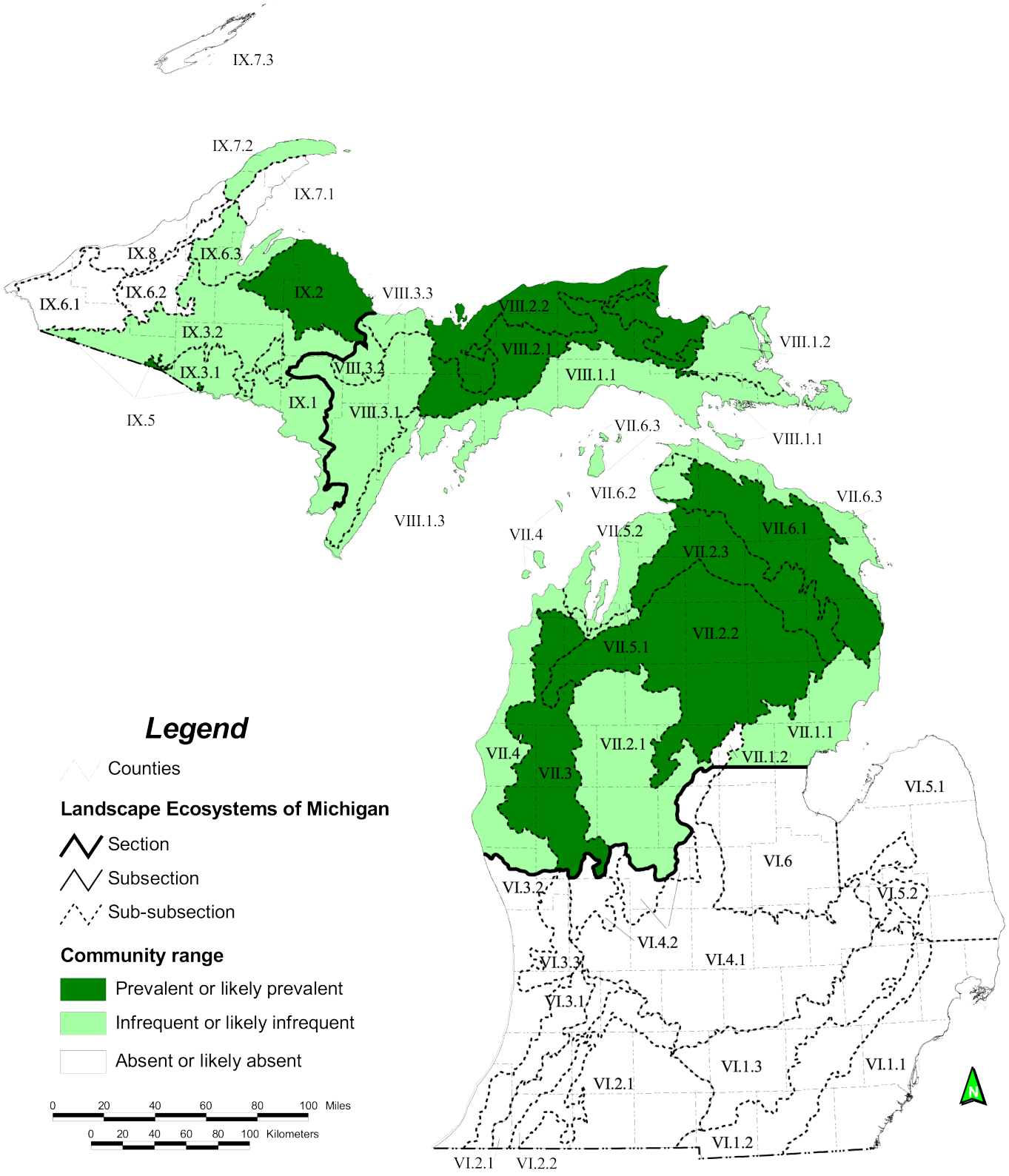

Ecoregional map of Michigan (Albert 1995) depicting distribution of dry northern forest (Albert et al. 2008)

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ceeding to more shade-tolerant hardwoods and aspens (Abrams and Scott 1989, Radeloff et al. 1999). In many areas where forest failed to regenerate, red and white pine plantations were established and maintained. Successional forests of aspen and birch that replaced some dry northern forests have been maintained and expanded by intensive silviculture and wildlife management geared toward promoting pulp production and providing favorable habitat for game species of early successional hardwood forests, particularly white-tailed deer, turkey and grouse.

Old-growth forest has dwindled from 68% to 5.2-8.3% of the Great Lakes landscape (Frelich 1995). Of the remaining old-growth in the Lake States, just 3.1% (1.6 million acres) is red pine/white pine forest. Remnants of red pine–dominated dry northern forest unscathed by logging are among the rarest vegetation types in the Lake States; primary red pine/white pine forest is merely 0.6% of the presettlement old-growth red pine/white pine forest (Frelich 1995). Currently there are 14 documented occurrences of the dry northern forest community in Michigan dominated by red pine. Only 6 of those occurrences, constituting just over 600 acres, are high-quality representations of this type. This rare variation of this community constitutes less than 0.01% of the present vegetation of Michigan. In contrast, jack pine–dominated dry northern forest constitutes 0.9% of the current vegetation. Jack pine–dominated dry northern forest occurs on over 1.8 million acres in Michigan, Minnesota and Wisconsin (Johnson 1994). Prior to European settlement, dry northern forests occurred on about 1.13 million acres of Michigan (3.0%) (Comer et al. 1995). Presently, jack pine–dominated dry northern forest is found on approximately 330,000 acres.

Physiographic Context: Dry northern forests occur principally on sandy glacial outwash and sandy glacial lake plains and less often on sand ridges in peatland complexes on glacial outwash or glacial lake plains (Curtis 1959, Brubaker 1975, Whitney 1986, Fisher 1994). Prevalent topographic positions of this community are low flat areas and gently undulating slopes (Collins 1958). This forest type often occurs on the driest and poorest sites in a landscape (Cayford 1970), distant from or west of natural fire breaks (Heinselman 1973) and adjacent to more fire-prone communities like pine barrens, oak-pine barrens and dry sand prairie (Comer et al. 1995). The soils of dry northern forest are typically coarse-textured, well-sorted, excessively drained sands characterized by extreme to very strong acidity, low nutrient content, low organic matter, low water-holding capacity and drought and frost proclivity (Livingston 1905, Potzger 1946, Zimmerman 1956, Curtis 1959, Whitney 1986, Fisher 1994).

Photo by Josh Cohen

In the Upper Peninsula, red pine frequently dominates inland dune ridges within peatland complexes.

The Michigan range of the dry northern forest falls within the area classified by Braun (1950) as the Northern Hardwood-Conifer Region (Hemlock/White Pine/Northern Hardwoods Region) and within the following regions classified by Albert et al. (1986): Region II, Northern Lower Michigan; Region III, Eastern Upper Michigan; and Region IV, Western Upper Michigan. The Northern Hardwood-Conifer Region has a cool snow-forest climate with short, warm summers, cold winters and a large number of cloudy days. The daily maximum temperature in July ranges from 24 to 29 °C (75 to 85 °F), the daily minimum temperature in January ranges from -21 to -9 °C (-5 to 15 °F) and the mean annual temperature is 7 °C (45 °F). The mean number of freeze-free days is between 90 and 160, and the average number of days per year with snow cover of 2.5 cm or more is between 80 and 140. The normal annual total precipitation ranges from 740 to 900 mm with a mean of 823 mm (Albert et al. 1986, Barnes 1991). Dry northern forests occur in a region that is characterized by a short growing season. As noted by Zimmerman (1956) jack pine–dominated forests occur where the growing season ranges between 84 and 127 days.

Natural Processes: Dry northern forests originate in the wake of stand-leveling fire. The natural disturbance regime in jack pine–dominated dry northern forests is characterized by catastrophic fire. Infrequent stand-leveling crown fires and frequent stand-perpetuating surface fires characterize the natural disturbance regime of red pine–

dominated dry northern forests. Presently, the prevalent catalyst of fires is lightning strike or human accident, but historically, Native Americans played an integral role in the fire regime, intentionally or accidentally setting fire to fire-prone ecosystems (Day 1953, Chapman 1984). Catastrophic stand-leveling fires within dry northern forests typically occur during spring and early summer when pine foliar moisture is low, needle starch content is high and subsequently, pine foliage is highly flammable (Van Wagner 1983, Cayford and McRae 1983). Large-scale, stand-replacing fires also occur during prolonged summer droughts (Heinselman 1973). Within the Mack Lake area of north central Lower Michigan, four times more area has burned during the second week in May than in other periods (Simard and Blank 1982). Conditions conducive to severe crown fire include rainless periods for two weeks or more, several days of low relative humidity, high temperatures and winds and lightning storms of limited extent (Van Wagner 1983).

Photo by David Kenyon, Michigan DNR

Fuel continuity and flammable characteristics of jack pine forests increase the probability of crown fires.

After catastrophic fires in these systems, a patchy mosaic of surviving trees and clumps of trees typically remains and can serve as seed or shelter trees (Vora 1994). In areas where jack pine was prevalent prior to the fire, jack pine can regenerate in very dense "dog-hair" stands with upwards of 16,800 trees/ha (Radeloff et al. 1999). Even if all canopy-dominant jack pine were killed by a catastrophic fire, this post-fire pioneer species can regenerate because jack pine's serotinous cones open and release an inundating seed rain after exposure to intense heat (Van Wagner 1983). The cone scales are held together with a resinous bonding material that melts between 32 and 50 °C (90 and 122 °F) (Cayford 1970, Cayford and McRae 1983). The small radicles of pine seeds cannot penetrate leaf litter or duff and require exposed mineral substrate. Crown fire prepares a mineral seed bed for germination, releases nutrients, eliminates vegetative competition and creates open conditions required by the intolerant seedlings (Brubaker 1975, Cayford and McRae 1983, Abrams and Dickman 1982). Jack pine cones each contain approximately 25 viable seeds (Cayford 1970), and a stand of jack pine can produce up to five million seeds/ha (Cayford and McRae 1983). Following the Mack Lake burn in north central Lower Michigan, scientists estimated the seed rain to be 750,000 seeds/ha and seedling regeneration to range from 5,000 to 42,500 seedlings/ha (Walker 1999). Post-fire jack pine stands are characteristically dense and even-aged, occasionally containing canopy components of northern pin oak, which re-sprouts from roots, or supercanopy red pine and white pine, which seed in from surviving canopy trees or adjacent forests. Jack pine is an early and proficient seed producer, bearing cones between three and five years and producing significant yields by age ten (Cayford and McRae 1983).

As well as higher seed production, flammability of young jack pine stands increases with time (Van Wagner 1983). In addition to occurring in dense stand conditions, which is correlated with flammability (Bond and Midgely 1995), jack pine have several combustible properties, including low foliage moisture and high levels of terpenes and resins (Whitney 1986, Fonda 2001). Jack pine stands are characterized by branch retention and between-tree interlocking of these tough dead branches, which creates vertical and horizontal fuel ladders (Johnson 1994, Zimmerman 1956). Such fuel continuity and flammable characteristics facilitate crown fire development (Stocks 1989). Cayford and McRae (1983) posited that young to semi-mature stands of jack pine are most susceptible to crown fires. Repeated fire intervals of greater than ten years can perpetuate jack pine forests given the early production of seed as noted above. Curtis (1959) speculated that jack pine could retain dominance of an area as long as fire occurs with a periodicity of 10 to 200 years and thereby prevents succession by mid-tolerant or tolerant species. Heinselman (1981) reported a return interval of approximately 50 years for catastrophic crown fires in jack pine forests of the Boundary Waters Canoe Area of Northern Minnesota. For the jack pine forests of the northern Lower Peninsula of Michigan, Whitney (1986) estimated a fire return interval of 80 years for intense crown fires. Within jack pine systems in the Mack Lake

area, Simard and Blank (1982) estimated fire intervals to range from 10 to 30 years.

To reproduce in the wake of severe crown fires, individual red pine must survive the catastrophe because their seed crops are intermittent and their cones are not serotinous (Heinselman 1973). If seed trees are nearby, white pine and red pine invade open areas cleared by fire or become established in the understory of pioneer stands of jack pine, aspen and/or birch. Curtis (1959) speculated that the presence of a nurse or shelter crop of trembling aspen, bigtooth aspen and/or white birch promotes mid-tolerant pine regeneration. After 30 years, the canopy of the pioneer species begins to open up, allowing for the ascendance to canopy dominance of pines and hardwood mid-tolerants. Once established in the overstory, a red pine cohort can remain intact for 150-350 years (Heinselman 1973). Heinselman (1981) reported a return interval of 150-200 years for catastrophic crown fires in red and white pine forests of the Boundary Waters Canoe Area of Northern Minnesota. For the red and white pine forests of the northern Lower Peninsula of Michigan, Whitney (1986) estimated a fire return interval of 120-300 years for intense crown fires. These systems also experienced frequent, low-intensity surface fires that burned the fire-prone, well-aerated needle mat and the shrub and seedling layer (Curtis 1959, Van Wagner 1970, Heinselman 1981, Quinby 1991). Red pine seedlings typically become established on exposed mineral soils and where competition from tolerant species is minimal. Ground fires provide excellent seedbeds for red pine by exposing mineral soil, retarding invasion of mesophytic species, controlling vegetative competition and providing light for the intolerant seedlings (Van Wagner 1970, Barnes 1989, McRae et al. 1994). Mature red pine can survive these surface fires due to their fire-resistant characteristics. Mature red pines have thick insulating bark (2-5 cm) and are tall (20-40 m) with their first branches occurring high above the ground (often 15 m). These characteristics prevent low-intensity fires from climbing to the crown.

Variation in fire intensity, timing and frequency, which influences the composition, structure and successional character of dry northern forests, is determined by climatic conditions, soil texture, topography, current vegetation and landscape context (i.e., proximity to water bodies and fire-resistant and fire-conducive plant communities) (Bowles et al. 1994, Chapman et al. 1995). On coarse-textured soils, which are favorable to pine, fires occurred often enough to maintain pine dominance in the canopy and favor pine regeneration (Stearns 1950, Whitney 1986). Stearns found that on more fertile and moist sites, an understory of mesophytic species can develop and becomes dominant in the absence of fire. Following the advent of hardwoods, the probability of frequent surface fire decreases due to the increase in moisture of the forest (Curtis 1959). As the result of fire suppression, most red pine–dominated dry northern forests are failing to regenerate pine and mid-tolerant species and are being invaded in the understory and canopy by tolerant species (Johnson 1994). Fire-starved and unmanaged jack pine systems are also threatened by tolerant species replacement (Brown and Curtis 1952, Cayford and McRae 1983). As noted by Mutch (1970), species with flammable properties are not adapted to prolonged fire exclusion, and as a result, fire-dependent conifer communities are threatened by impending succession to more mesic, hardwood conditions. However, low cone serotiny (cones opening while on adult trees in the absence of fire) occurs and has occasionally been observed in uneven-aged jack pine forests that contain vigorous jack pine seedlings growing interspersed with adult conspecifics: Brubaker (1975) found this to be a common type in the Yellow Dog Plains in the western Upper Peninsula. McRae et al. (1994) argued that in the absence of fire, the sustained canopy dominance and regeneration of red pine and white pine is assured only on rocky and sandy sites where hardwood competition is slight. Red pine–dominated inland dune ridges in the Upper Peninsula adjacent to beaver-inhabited wetlands are often lacking a hardwood component in the canopy and seedling and sapling layers. It is possible that beaver play a crucial role in selectively harvesting mesophytic hardwood species from these systems.

The natural disturbance regime in dry northern forests is also influenced by wind, insect epidemics and periodic freezes. The Great Lakes region is one of the most active weather zones in the northern hemisphere, with polar jet streams positioned overhead much of the year. More cyclones pass over this area than over any other region in the continental U.S. (Frelich and Lorimer 1991). Canham and Loucks (1984) found that blowdowns in presettlement forests of northern Wisconsin occurred in all major forest types and that there was a continuous spectrum of windthrow from small tree-fall gaps to large contiguous patches of several thousand acres. Susceptibility of forest to blowdown and catastrophic windthrow is determined by stand composition, age, structure and local topography. Catastrophic windthrow is an important yet infrequent component of the disturbance regime of the dry northern

forests. Winds greater than 200 km/hr can cause heavy destruction, removing 60-70% of the canopy basal area (Frelich and Lorimer 1991). Canham and Loucks (1984) estimated the return time for large-scale windthrow (> 1.0 ha) to be 1,210 years in forests of northern Wisconsin. The principal mechanisms for large-scale windthrow are tornadoes and downbursts from thunderstorms. Downbursts are parcels of air in downdrafts that shoot out from the base of thunderstorms and splatter in all directions upon impact with the earth (Frelich and Reich 1996). Severe low-pressure systems are a significant source of small-scale canopy gaps, which can generate diversity of age structure in these stands (Canham and Loucks 1984). Both windthrow and insect epidemics are correlated with increased probability of severe crown fire because they lead to overstory mortality and increased fuel loads (Heinselman 1973, Radeloff et al. 1999). Over 58 species of insect are known to feed extensively on jack pine; of these, 25 cause serious damage. Jack pine budworm (*Choristoneura pinus pinus* Freeman) is the most severe insect defoliator of jack pine. Outbreaks typically last two to four years and result in reduced tree growth and often extensive tree mortality from defoliation (Conway et al. 1999). Mortality from periodic frosts typically affects northern pin oaks and pine seedlings growing in areas of low elevation (Kashian and Barnes 2000). Frost pockets within dry northern forest are often open from repeated, severe freezes.

Vegetation Description: The dry northern forest is a broadly defined community type with numerous regional, physiographic and edaphic variations (Brown and Curtis 1952, Curtis 1959). Variation in disturbance intensity, seasonality and frequency influences the composition, productivity, structure and successional character of this system. The main dominants of this community are *Pinus banksiana* (jack pine), *Quercus ellipsoidalis* (northern pin oak) and *Pinus resinosa* (red pine). Canopy associates include *Acer rubrum* (red maple), *Betula papyrifera* (paper or white birch), *Pinus strobus* (white pine, which occasionally occurs in the supercanopy), *Populus grandidentata* (bigtooth aspen), *Populus tremuloides* (trembling aspen), *Prunus serotina* (black cherry) and *Quercus rubra* (red oak). Mesophytic invasion of dry northern forest is favored by fire exclusion. Tree species associated with this community but most commonly found in the subcanopy include: *Abies balsamea* (balsam fir), *Picea glauca* (white spruce) and *Picea mariana* (black spruce). The relative importance of these trees differs locally and regionally. Significant variation in community composition is proportional to marked differences in local topography, soil, disturbance factors (natural and anthropogenic), geographic context and biotic factors such as competitive interactions and browsing pressure (Alverson et al. 1988, Barnes 1991, Palik and Pregitzer 1992). Jack pine, a "frugal scrub among the stately race of evergreens," is the most common canopy dominant of this forest type and often is the sole dominant (Cayford and McRae 1994). Two major vegetative variants are prevalent: jack pine/jack pine–hardwood–dominated and red pine–dominated. Jack pine or mixed jack pine forest occurs on expanses of dry sandy outwash plains especially in the northern Lower Peninsula. Jack pine forest with a minor component of northern pin oak typically occurs adjacent to pine barrens on Michigan's most fire-prone landscapes. Prior to fire exclusion, the boundary between these two types was probably in continual flux, depending on wildfire frequency. Red pine often shares canopy dominance with jack pine on the sandy outwash plains, forming a scattered supercanopy. Dry-mesic northern forest (red pine/white pine forest) often occurs on moraines downwind from more fire-prone jack pine/red pine forest. Red pine–dominated systems occur on inland dune ridges within peatland complexes and also on high elevation ice-contact island ridges within jack pine or jack pine/red pine–dominated outwash plains (Comer et al. 1995).

Dry northern forests dominated by jack pine are typically dense, even-aged stands with simple overstory composition and structure (Brown and Curtis 1952). Where red pine or white pine forms a scattered supercanopy, the community exhibits a unique, two-tiered structure. Red pine–dominated systems are also even-aged but less dense than jack pine systems. Jack pine forests exhibit a wide range of diameters and tree heights. Diameters at breast height (dbh) range from 10 to 25 inches (3.9 to 9.8 cm), but jack pine growing on unproductive sites often ranges between 3 and 8 inches (1.2 to 3.1 cm). Jack pine tree height ranges widely from 20 to 100 feet depending on site quality (Zimmerman 1956, Johnson 1994). Jack pine on high-elevation landforms grows faster and in denser stands than jack pine in adjacent low-elevation landforms. Variation in growth is correlated with difference in air temperature and soil moisture and fertility, with warmer temperatures and moister, more fertile soils in the high elevations (Palmgren 1999, Walker 1999, Kashian and Barnes 2000). Average mature red pine can be 80 feet (24.4 m) tall and 3 feet (91.4 cm) in diameter, but trees up to 150 feet (45.7 m) tall and 5 feet (152.4 cm) in diameter have been documented (Johnson 1994). Collins (1958)

Dry northern forest is a pine- or pine-hardwood-dominated forest type that occurs on dry sandy sites lying mostly north of the climatic tension zone. Two distinct variants are included within this community type, one dominated by jack pine (above) or jack pine and hardwoods, and the other dominated by red pine (below). Photos by Joshua G. Cohen.

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systematically sampled the remaining old-growth red pine stands of the northern Lower Peninsula and found mean stand height to range from 70 to 107 feet (21.3-32.6 m) and mean diameter at breast height (dbh) to range from 16.9 to 21.6 inches (42.9-54.9 cm). Within red pine–dominated stands surveyed by MNFI, dbh varied from 15.7 to 27.6 inches (40-70 cm). The canopy layer of this community varies widely from relatively open to relatively closed (25-70% cover) (Zimmerman 1956). The light intensity on the forest floor decreases as the shade tolerance of the dominant canopy species increases: more light filters through to the forest floor in pure pine stands compared to pine-hardwood stands. Ground layer coverage ranges between 60 and 100%. The number of species and percent coverage in the ground layer decreases as the amount of shade provided by tree canopy increases (Zimmerman 1956). In addition, vascular plant diversity increases temporarily following fire (Abrams and Dickman 1982). Compared to mesic northern forests, more understory species of dry northern forests bloom throughout the course of the summer (Curtis 1959). The dry and acidic conditions in dry northern forests result in low vascular plant diversity (Palmgren 1999).

Photo by Joshua G. Cohen

Dry northern forests dominated by jack pine are characteristically dense, even-aged stands with simple structure and floristic composition.

Numerous evergreen herbs and shrubs and a preponderance of prostrate plants of creeping habit characterize dry northern forests. The low shrub component is pervasive and dominated by ericaceous plants, which spread by runners or creeping rhizomes and tend to form tight colonies (e.g., *Arctostaphylos uva-ursi* [bearberry], *Cornus canadensis* [bunchberry], *Epigaea repens* [trailing arbutus], *Gaultheria procumbens* [wintergreen], *Gaylussacia baccata* [huckleberry] and *Vaccinium* spp. [blueberries]). The tall shrub layer is typically scanty (Zimmerman 1956, Curtis 1959). Shrub species within this community have the capacity to stump sprout following fire (Carroll and Bliss 1982). A unique feature of this forest type is the prevalence of mosses (*Dicranum* spp.), feathermoss (*Pleurozium schreberi*) and lichens (*Cladina* and *Cladonia* spp.), which often form a continuous mat over the soil. *Pteridium aquilinum* (bracken fern) is the prevalent fern species found in dry northern forests, and it frequently is the dominant plant in the ground layer. Open areas within dry northern forests share many of the same species as pine barrens (see pine barrens abstract).

Prevalent herbs of the dry northern forest include: *Andropogon gerardii* (big bluestem), *Apocynum androsaemifolium* (spreading dogbane), *Aralia nudicaulis* (wild sarsaparilla), *Aster macrophyllus* (big-leaved aster), *Aster sagittifolius* (arrow-leaved aster), *Brachyelytrum erectum, Campanula rotundifolia* (bluebell), *Carex lucorum* (blue ridge sedge), *Carex pensylvanica* (Pennsylvania sedge, which can completely dominate the ground layer in the absence of fire), *Chimaphila maculata* (striped wintergreen), *Cornus canadensis*, *Danthonia spicata* (poverty oats), *Deschampsia flexuosa* (hair grass), *Epigaea repens*, *Fragaria virginiana* (wild strawberry), *Maianthemum canadense* (Canada mayflower), *Melampyrum lineare* (cow-wheat), *Mitchella repens* (partridge berry), *Oryzopsis asperifolia* (rice grass), *Oryzopsis pungens* (rice grass) and *Schizachyrium scoparium* (little bluestem). Abrams and Dickman (1982) observed that recently burned sites have more vascular plants than undisturbed sites. In fire-suppressed systems, Pennsylvania sedge, which often forms a dominant mat, monopolizes resources, suppresses other ground layer species and contributes to the failure of jack pine regeneration. Pennsylvania sedge appears susceptible to injury from hot fires, and recently burned sites tend to exhibit an increase in the importance of perennial herbs and grasses (Abrams and Dickman 1982). Numerous invasive exotics are dominant components in the ground layer of openings within dry northern forests, especially where fire has been excluded. Prevalent invasive plants

include *Centaurea maculosa* (spotted knapweed), *Hieracium* spp. (hawkweeds*), Rumex acetosella* (sheep sorrel), *Poa pratensis* (Kentucky bluegrass), *Phleum pratense* (timothy) and *Verbascum thapsus* (common mullein).

Characteristic shrubs include: *Amelanchier* spp. (serviceberry)*, Arctostaphylos uva-ursi*, *Ceanothus* spp. (New Jersey Tea), *Comptonia peregrina* (sweetfern), *Diervilla lonicera* (bush-honeysuckle), *Gaultheria procumbens*, *Gaylussacia baccata*, *Hamamelis virginiana* (witch hazel), *Hudsonia tomentosa* (beach-heath), *Juniperus* spp. (junipers), *Linnaea borealis* (twinflower), *Prunus pumila* (sand cherry), *Prunus virginiana* (choke cherry), *Rubus flagellaris* (northern dewberry)*, Salix humilis* (prairie willow), *Vaccinium angustifolium* (low sweet blueberry), *Vaccinium myrtilloides* (velvetleaf blueberry), *Vaccinium vacillans* (early low blueberry). (Above species lists compiled from MNFI database and from Livingston 1905, Brown and Curtis 1952, Zimmerman 1956, Curtis 1959, Byer 1960, Gleason and Cronquist 1964, Cayford 1970, Brubaker 1975, Van Wagner 1983, Abrams and Dickman 1982, Palmgren 1999, Walker 1999, Faber-Langendoen 2001 and NatureServe 2001.)

Michigan indicator species: *Pinus banksiana* (jack pine), *Pinus resinosa* (red pine) and *Quercus ellipsoidalis* (northern pin oak) within a forested system.

Other noteworthy species: Dry northern forests of Michigan provide breeding habitat for *Dendroica kirtlandii* (Kirtland's warbler, federally endangered and state endangered). During the summer breeding season, this neotropical migrant depends upon large, relatively homogenous stands of jack pine with scattered small openings. The specific nesting habitat is further restricted to concealing ground vegetation near jack pines at least 6 to 8 feet tall (i.e., 5-20 years old). Once jack pines reach a height greater than 18 feet, the lower branches begin to drop and the shade-tolerant ground cover changes in composition, thereby leading to unfavorable nesting conditions. Dry northern forests also provide habitat for *Dendroica discolor* (prairie warbler, state endangered) which nests in early successional stages within the jack pine plains.

Dry northern forest and surrounding dry sand prairie, pine barrens and oak-pine barrens share a rich diversity of invertebrates including numerous butterflies, skippers and grasshoppers. Rare butterflies, skippers and moths include: *Atrytonopsis hianna* (dusted skipper, state special concern), *Erynnis p. persius* (persius duskywing, state threatened), *Hesperia ottoe* (ottoe skipper, state threatened), *Incisalia henrici* (Henry's elfin, state threatened), *I. irus* (frosted elfin, state threatened), *Papaipema beeriana* (blazing star borer moth, state special concern), *Pyrgus centaureae wyandot* (grizzled skipper, state special concern) and *Merolonche dolli* (Doll's merolonche moth, state special concern). *Appalachia arcana* (secretive locust, state special concern) occur in bogs within dry northern forests and are frequently found utilizing the surrounding upland forest. Other rare invertebrates include *Lepyronia gibbosa* (Great Plains spittlebug, state special concern), *Oecanthus pini* (pine-tree cricket, state special concern), and *Prosapia ignipectus* (red-legged spittlebug, state special concern).

Several rare raptor species frequently nest in dry northern forests in which canopy red pine or white pine is present; *Accipiter gentilis* (Northern goshawk, state special concern), *Haliaeetus leucocephalus* (bald eagle, state special concern) and *Pandion haliaetus* (osprey, state special concern). *Falco columbarius* (merlin, state threatened) could occur within dry northern forests that are adjacent to wetlands or within close proximity of the Great Lakes shoreline. *Picoides arcticus* (black-backed woodpecker, state special concern) forage in dry northern forests that have a significant component of standing dead trees (Evers 1991). Rare reptiles known from this community type include *Sistrurus catenatus catenatus* (eastern massasauga, state special concern, federal candidate species) and *Terrapene carolina carolina* (Eastern box turtle, state special concern).

Rare plants associated with areas of open canopy in dry northern forest include *Agoseris glauca* (pale agoseris, state threatened), *Cirsium hillii* (Hill's thistle, state special concern), *Diphasiastrum alpinum* (Alpine clubmoss, presumed extirpated from Michigan), *Festuca scabrella* (rough fescue, state threatened), *Oryzopsis canadensis* (Canada rice-grass, state threatened) and *Prunus alleghaniensis* var. *davisii* (Alleghany or sloe plum, state special concern). *Pterospora andromedea* (pine drops, state threatened) can occur in dry northern forests with well-developed needle duff.

Conservation/management: When the primary conservation objective is to maintain biodiversity in dry northern forests, the best management is to leave large tracts unharvested and encourage the operation of natural processes (fire, growth, senescence, windthrow, disease, freezing, insect infestation etc.). Long-term preservation

of dry northern forest communities depends on the promotion of fire (or an equivalent anthropogenic disturbance) as the prime ecological process driving persistence and establishment. Heinselman (1973) argued that managers can re-establish the natural fire regime of these systems with prescribed burning. To duplicate the disturbance regime of crown and ground fire (for red pine systems), he proposed a combination of spring, summer and fall burns based on lightning fire frequency. Prescribed fire and wildfire result in site preparation for pine (opening of serotinous cones and exposure of mineral soil), release of nutrients, slash removal, hazard reduction, elimination of vegetative competition, reduction of fungus, insects and parasitic plants and creation of open conditions required by the intolerant seedlings (Cayford 1970, Cayford and McRae 1983). The effects of wildfire and prescribed fire are highly variable depending on the frequency, timing and intensity of the burn and the current vegetation. Intense crown fires in young pine stands provide the opportunity for post-fire hardwood dominance by facilitating stump sprouting and seeding in of hardwoods. Hardwood stump sprouts can be controlled with herbicide. Longer fire intervals (10 to 80 years for jack pine and 80 to 130 years for red pine) promote pines because hardwoods die out. In addition, intense fires that burn deep into the organic layer promote post-fire pine dominance because deep burns limit the capacity of vegetative reproduction of hardwoods (Van Wagner 1983). Given the high flammability of pine systems during the spring and early summer months and during prolonged droughts, extra fire management precautions should be taken under these conditions (Simard and Blank 1982).

Where prescribed fire is not feasible, mechanical manipulation can be utilized to replace both ground fire (for red pine systems) and catastrophic crown fire (Heinselman 1973, Chown et al. 1986). Mechanical site preparation avoids risks associated with prescribed burning, provides managers with more flexibility with respect to timing and is less labor intensive (Cayford 1970). Chown et al. (1986) suggest that the effects of surface fire can be mimicked by mechanically scarifying the soil, girdling or herbiciding competing vegetation and under-planting pine seedlings. Catastrophic crown fire can be imitated by clear-cutting all but a patchy mosaic of pine trees and clumps of trees to serve as seed trees and scarifying the mineral soil. Exposure of mineral soil can be accomplished with prescribed fire or the use of a diverse array of front-mounted or rear-mounted equipment. Naturally regenerated dry northern forests often are characterized by a spotty distribution of pine seedlings, and jack pine regeneration is scarce following prescribed slash fires in clear-cuts because of the destruction of cones in the slash. The maintenance of canopy seed trees following a clear-cut can facilitate the establishment of satisfactory pine regeneration (Cayford 1970, Johnson 1994). Where pine regeneration is inadequate, planting may be required. Johnson (1994) recommends direct seeding of 20,000 jack pine seeds/acre in the spring and at least 60% exposure of mineral soil.

Where remnants of red pine–dominated dry northern forest endure, compositional stability of pine is jeopardized because of fire suppression and the subsequent invasion of mesophytic species and the threat of severe crown fire. Fire exclusion increases the risk of extremely severe fire due to excessive fuel loading in the understory and subcanopy (Chown et al. 1986). In dry northern forests in which pine is not self-replacing, understory prescribed burning can promote pine regeneration and reduce the probability of severe crown fire. Low-intensity surface fires (underburns) favor red pine seedling establishment and growth by preparing a suitable seedbed, releasing nutrients and controlling vegetative competition. Under-burned stands often exhibit a mosaic of open, partial and full canopy. Ground fire scorching of overstory and subcanopy trees can result in patchy removal of portions of the canopy, which increases light and encourages seedling growth. According to McRae et al. (1994) optimum stand age for understory prescribed burning to promote red pine regeneration is between 50 and 150 years. When pine trees reach 80 years, their bark becomes thick enough to protect from mortality caused by surface fires. To promote natural seeding, prescribed burning should be employed during years of high seed production and in the spring when seed production peaks. Burning to control vegetative competition often requires multiple burns within the same year or in consecutive years. Typically, one fire is sufficient to girdle understory balsam fir, a thin-barked species. However, multiple fires are required to control hardwood encroachment. Control of hardwood competition often can be achieved by two consecutive annual fires (Van Wagner 1970). In dry northern forests in which aspen is prevalent in the overstory or understory, prescribed burning or selective cutting of the aspen can result in extensive aspen sprouting and the subsequent promotion of aspen dominance. In such circumstances, if pine is the management objective, patience is perhaps the best management option. As noted by Curtis (1959) a nurse or shelter crop of aspen or birch can promote pine regeneration. Given the scarcity of red pine–dominated dry northern forests

compared to jack pine systems, conservation efforts should be focused on preserving and promoting this rare type.

The preservation of biodiversity of dry northern forests and timber management are not mutually exclusive. When tracts of dry northern forest are being managed for timber harvest, care should be taken to minimize fragmentation and roads, preserve as much area as possible in a forested matrix, maintain a range of canopy closure across the landscape comparable to pre-harvest closure, retain conifer seed trees and utilize fire or mechanical manipulation to promote conifer regeneration. The baseline for the fire management or mimicking mechanical manipulation of natural stands is the patch size and return interval of fire disturbance for a given landscape (Fisher 1994). Current research indicates that prior to European settlement of the Lake States, in red pine–dominated forests catastrophic crown fires had a return interval of between 120 and 300 years (Heinselman 1973, Whitney 1986) and ground fires occurred frequently and with low intensity (Heinselman 1973, Whitney 1986, Quinby 1994) suggesting a short return interval (between 5 and 20 years). The interval for crown fire in jack pine systems ranges from 10 to 80 years (Curtis 1959, Heinselman 1973, Simard and Blank 1982, Whitney 1986). In Michigan, the original land surveyors frequently observed catastrophic fires several square miles in area (Comer et al. 1995). Frelich and Lorimer (1991) estimated the maximum size of an individual downburst in the Great Lakes region to be 3,785 ha. Prior to fire suppression, vast areas of windthrow typically burned over. Given the large scale of the catastrophic disturbance to the landscape, recovery from perturbation requires protection of substantial areas of dry northern forest. Red pine–dominated dry northern forest complexes designated as old-growth or potential old-growth forest should be larger than the area potentially altered by catastrophic disturbance or they need to be replicated several times across the landscape (Vora 1994). Management of dry northern forest communities should be orchestrated in conjunction with the management of adjacent communities such as pine barrens, oak-pine barrens, dry-mesic northern forest and mesic northern forests.

Pine plantations, scrub oak and aspen and birch forest now occupy vast areas of former dry northern forest. Restoration of dry northern forest from pine plantations, scrub oak and birch forest can be accomplished by employing the above techniques of burning, planting and/or mechanical site preparation. In areas dominated by aspen where pine seed trees persist and pine regeneration is pervasive in the understory, the best management strategy is patience as the successional stands provide a beneficial shelter crop for pine regeneration. However, due to the lack of pine seed trees (especially red pine), restoration may require intensive tree planting efforts in conjunction with patience, prescribed fire and/or anthropogenic manipulation.

Research needs: The dry northern forest exhibits numerous regional, physiographic and edaphic variants. The diversity of variations throughout its range demands the continual refinement of regional classifications that focus on the inter-relationships between vegetation, physiography and soils (Barnes et al. 1982). Investigation into the frequency, periodicity (seasonality), patch size and intensity of surface and crown fires in dry northern forest is needed to guide restoration and management activities. Use of prescribed fire demands a better understanding of forest fire behavior as influenced by weather, fuels, topography and vegetation (Van Wagner 1983). Given the historical importance of catastrophic fire, insect epidemics and windthrow in this system, an important research question to be addressed is how the disturbance regime, structure and species composition of this community will change as the Great Lakes region becomes increasingly fragmented. It is important to understand the ramifications of fire exclusion in dry northern forests to its flora and fauna, nutrient cycling, energy pathways and landscape patterns (Heinselman 1973). Experimentation is needed to determine how best to utilize surface fire to manipulate competitive mesophytic vegetation, pine recruitment and canopy structure in red pine–dominated systems: How are fire frequency, timing and intensity related to understory hardwood mortality, pine seedling regeneration and windfall of canopy trees? The abundance of beaver in wetlands surrounding dry northern forests begs the question: How do beaver influence recruitment and succession within this community? Because limitations imposed by safety concerns can hamper the effectiveness of prescribed fire (especially large-scale crown fires), maintaining the ecological integrity of dry northern forests requires experimentation with different anthropogenic disturbance combinations. Romme et al. (1998) pose the crucial question, Are large infrequent disturbances qualitatively different from small frequent disturbances? In other words, Can we substitute smaller, more controllable disturbance for dangerous, uncontrollable, large natural disturbance and still achieve the same management objectives? If not, we need to devise strategies for incorporating the large disturbances into our management framework. Effects of management need to be monitored to allow for assessment and refinement. The

prevalence of timber activity in this community demands increased post-harvest monitoring of rare and sensitive species that depend on dry northern forest.

Similar communities: boreal forest, dry-mesic northern forest, pine barrens, oak-pine barrens and wooded dune and swale complex

Other Classifications:

Michigan Natural Features Inventory Presettlement Vegetation (MNFI):
Jack Pine/Red Pine Forest (4213 and 4215) and Mixed Pine/Oak Forest (4218)

Michigan Department of Natural Resources (MDNR): J-Jack Pine, R-Red Pine, O-Oak

Michigan Resource Information Systems (MIRIS): 42 (Coniferous Forest), 421 (Upland Conifers), 4212 (Red Pine), 4213 (Jack Pine), 43 (Mixed Conifer-Broadleaved Forest), 431 (Upland Hardwoods and Pine), 4342 (Upland Hardwoods and Red Pine) and 4343 (Upland Hardwoods and Jack Pine)

The Nature Conservancy National Classification:
CODE; ALLIANCE; ASSOCIATION; COMMON NAME

I.A.8.N.b.2; *Pinus banksiana* Forest Alliance; *Pinus banksiana / Abies balsamea* Forest; Jack Pine / Balsam Fir Forest

I.A.8.N.b.2; *Pinus banksiana* Forest Alliance; *Pinus banksiana / Arctostaphylos uva-ursi* Forest; Jack Pine / Kinikinnick Forest

I.A.8.N.b.2; *Pinus banksiana* Forest Alliance; *Pinus banksiana - (Pinus resinosa) / Corylus cornuta* Forest; Jack Pine / Hazel Forest

I.A.8.N.b.2 ; *Pinus banksiana* Forest Alliance; *Pinus banksiana - Pinus resinosa - Pinus strobus* Dune Forest; Great Lakes Dune Pine Forest

I.A.8.N.b.2; *Pinus banksiana* Forest Alliance; *Pinus banksiana / Vaccinium* spp. */ Pleurozium schreberi* Forest; Jack Pine / Blueberry / Feathermoss Forest

I.A.8.N.b.12; *Pinus resinosa* Forest Alliance; *Pinus resinosa / Vaccinium* spp. Forest; Red Pine / Blueberry Dry Forest

I.C.3.N.a.10; *Pinus banksiana-Populus tremuloides* Forest Alliance; *Pinus banksiana-Populus tremuloides / Diervilla lonicera* Forest; Jack Pine-Aspen / Bush-honeysuckle Forest

I.C.3.N.a.11; *Pinus banksiana-Quercus (ellipsoidalis, velutina)* Forest Alliance; *Pinus banksiana-(Pinus resinosa)-Quercus ellipsoidalis / Carex pensylvanica* Forest; Jack Pine-Northern Pin Oak Forest

Related Abstracts: Alleghany plum, black-backed woodpecker, blazing star borer moth, dry-mesic northern forest, eastern box turtle, eastern massasauga, false violet, Hill's thistle, Kirtland's warbler, merlin, northern goshawk, oak-pine barrens, pale agoseris, pine barrens, pine drops, red-legged spittlebug, rough fescue and secretive locust.

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